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The Influence of Industry 4.0 on Reshoring

The Impact of the Fourth Industrial Revolution on Relocation Decisions

Master Thesis

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The Influence of Industry 4.0 on Reshoring

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Abstract

Within this paper, the influence of the fourth industrial revolution, also called Industry 4.0, on reshoring in the manufacturing industry has been researched. The goal of this research is to provide new points of view on relocation decisions within the context of Industry 4.0. This paper provides an insight to truly understand why or why not companies take reshoring decisions. This paper aims to present and facilitate an understanding of Industry 4.0 as a concept, its goals, enablers, and its total effect on the reshoring drivers. Industry 4.0 is described, and its influence on reshoring is presented. Through a semi-structured interview, eight manufacturing companies within the textile industry have been interviewed. A framework of reshoring and the effects of Industry 4.0 are addressed. An unanticipated factor of sustainability has been found and needs further research for a full understanding. Finally, the conceptual framework has been adopted, whereby the influence of Industry 4.0 on reshoring is integrated.

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1. Introduction

1.1 Industry 4.0 and reshoring

After an intense period of firms starting to offshore manufacturing and related activities, now another phenomenon is being observed: previously offshored activities are brought back to a domestic location, referred to as reshoring[1] (Gray et al., 2013; Fratocchi et al., 2014; Benstead, Stevenson, & Hendry, 2017). Reshoring is a recent phenomenon and therefore empirical evidence is scarce (Brennan et al., 2015, p. 1259; Fratocchi et al., 2014). Researchers are even still unclear whether reshoring is rare (Dachs and Zanker, 2014), while other researchers suggest that reshoring will most likely increase (Arlbjørn & Mikkelsen, 2014, p. 60; Kinkel, 2012, p. 712). However early data reports show that in 2017 the combined reshoring and the related foreign direct investment announcements in the United States surged. In total adding over 171,000 new jobs in 2017, with an additional 67,000 in revisions from 2010 to 2016 (Reshoring Initiative, 2017). 85% of companies that have reshored are active in the manufacturing industry (Eurostat, 2019). Almost 253 cases have been identified whereby European manufacturing companies have reshored their activities in the period from 2016 until 2018 (Eurofound, 2019). While reshoring is mainly driven driven by the manufacturing of products closer to the market (Vnachan, Mulhall & Bryson, 2018), the reshoring trend is especially visible in the fashion industry and it is even the highest type of industry to reshore (Eurofound, 2019). That is not surprising since it is predicted that by 2025 over 20% of all the apparel shall come from reshored sources (Amed et al., 2019).

Previously offshoring and outsourcing were strategies used to minimize effort into non-value adding activities. Later it was also used to minimize labor-related costs and costs related to components and end times (Hartman et al., 2017). Now, within the manufacturing industry, gradually less labor intensive production methods are used. This is mostly due to technological development and innovations in manufacturing technology. Multiple authors (Blanchet, Thieulloy, Rinn & Thaden, 2014, p.22; Handley and Benton, 2013; Foerstl, Kirchhoff & Bals, 2016) state that these technological developments are favoring reshoring decisions.

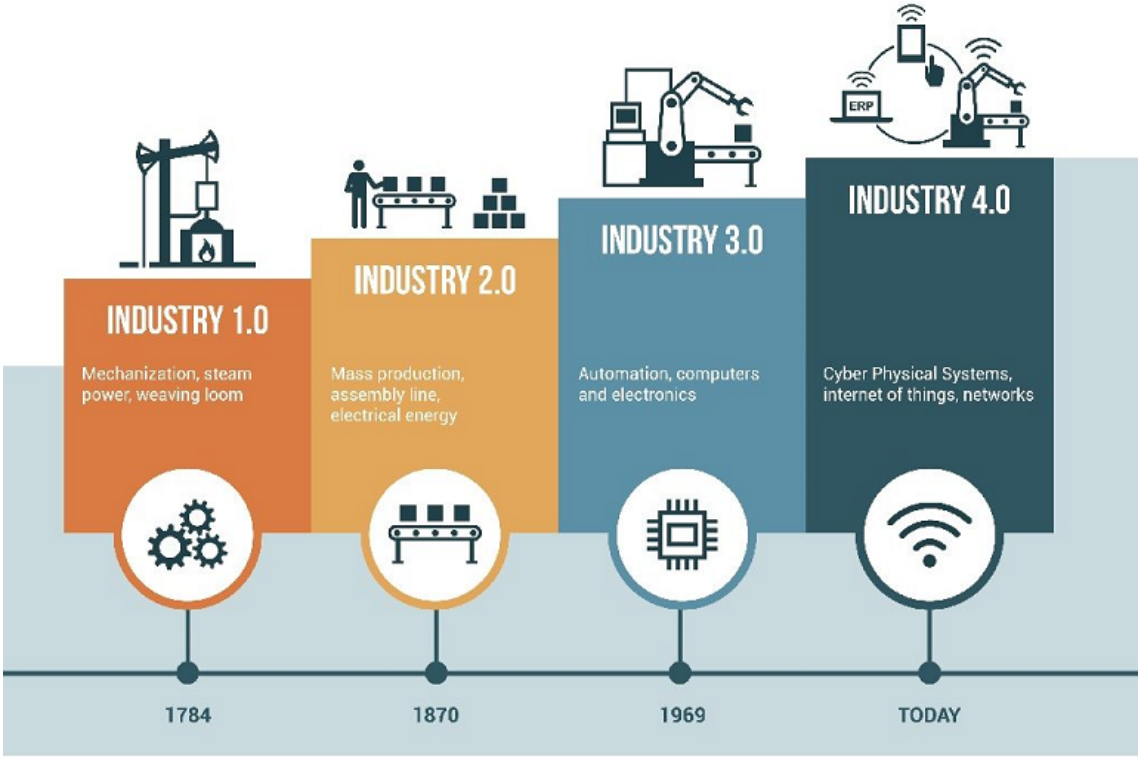
The rise of technological development and innovative production methods can be referred to as the collective term Industry 4.0 or smart industry, which is the fourth industrial revolution

[1] Multiple terms are used to describe reshoring, such as back-reshoring, inshoring, backshoring, back-sourcing and onshoring. In this research, the term reshoring will be used (Gray et al., 2013; Fratocchi et al., 2014).

(Barbieri et al., 2018). Industry 4.0 uniquely enables autonomous manufacturing cells to independently control and optimize manufacturing in various steps without requiring human analytics or intervention (Lasi et al., 2014). Earlier, industry 1.0 (18th century, mechanization), industry 2.0 (19th century, mass production) and industry 3.0 (20th century, automation) were referred to as previous industrial revolutions. The three first industrial revolutions (see Figure 1) had significant implications on companies' productivity and on society as a whole (Blinder, 2006). For instance, during the first industrial revolution, the mechanization caused large migration shifts and companies' output increased enormously (Blinder, 2006). The second period of industrial revolution is characterized by fast industrialization and was therefore also known as the technological revolution (Muntone, 2013). During this second revolution, efficient machinery was paired with new mass production techniques, which led to increased output and lower production costs for companies (Kanji, 1990). During the third industrial revolution, innovations like the microprocessor, transistor, telecommunications and the computer digitalized the manufacturing industry (Hammelscale, 2018).

It can be expected that on these grounds Industry 4.0 will have large implications as well, both for companies and for academic research. Rapid developments in automation and robotics have slowly erased competitive advantages in low-cost manufacturing countries (Kinkel, 2014). Therefore outsourcing benefits are decreasing and will decrease further in the future. The rapid growing technological developments are closely related to the field of Industry 4.0 and therefore are expected to cause an effect on reshoring. Taking all the above into consideration, it is it is interesting to investigate whether and how Industry 4.0 impacts reshoring.

Figure 1 – Overview of Four Industrial Revolutions



Source: Hammelscale (2018), https://www.hammelscale.com/industry-4-0/

1.2 Research question

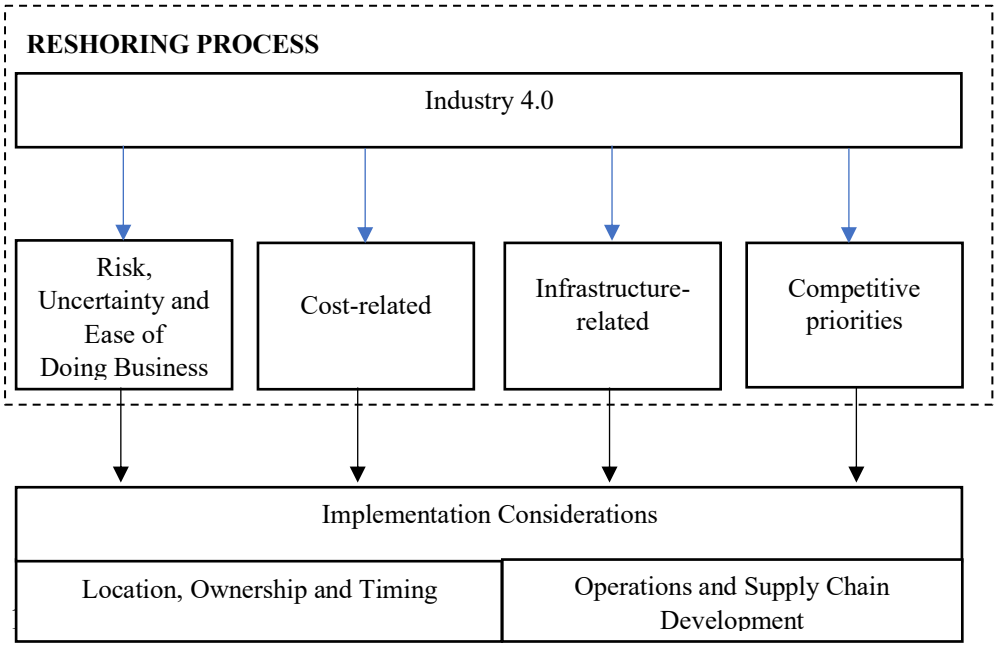
The purpose of the study is to investigate how Industry 4.0 impacts reshoring drivers in the manufacturing industry. Benstead, Stevenson and Hendry (2017) executed a case study and systematic literature review about reshoring. During their research they identified four reshoring categories, of which each consisted of several reshoring drivers. In the end, some of these drivers were supported by primary and/or secondary data. These drivers can be seen as relevant drivers, as they were supported by academic research. Their findings were summarized in a framework (see Figure 2), this will be the basis of the thesis, which means that the identified reshoring drivers are used as a guideline.

To achieve the research objective, the following research question should be answered:

Which reshoring decisions regarding (a) Risk, Uncertainty and Ease of Doing business, (b) Cost-related drivers, (c) Competitive priorities and (d) Infrastructure-related drivers are influenced by Industry 4.0 in the manufacturing industry?

The framework of Benstead, Stevenson and Hendry (2017) incorporated the effects of certain contingency factors such as company and industry related factors, product related factors and behavioral or individual related factors. In chapter 3, the relevant contingency factors for this research will be further elaborated. Following the original framework and since the implementation considerations are being influenced by the reshoring categories itself, the need for further research from Industry 4.0 and its influence on the implementation considerations itself will be left out.

Figure 2 – Conceptual Model



This research will provide manufacturing companies with new points of view on relocation decisions within the context of Industry 4.0. It may help managers to truly understand why or why not take reshoring decisions. As the research will be qualitative, it aims to find foundations to build a theory about reshoring decisions within the context of Industry 4.0 (Mitchell and Cody, 1993). The decisions within the manufacturing industry have long-term effects a company's competitiveness. Especially regarding reshoring impact management driven by relocation decisions (Dunning, 1980, p. 12, 14; Ferdows, 1997, p. 74; MacCarthy & Atthirawong, 2003, p. 794). It also impacts society, for instance more interest to reshoring has been shown in politics (Iozia & Leirião, 2014). This is explainable since a growing and healthy manufacturing sector stabilizes the economy (Foresight, 2013, p. 14). As this research points out how reshoring can be

interpreted within the context of Industry 4.0, managers can act upon that by adjusting their strategy.

1.3 Academic Contribution

Researchers have shown a growing interest in the phenomenon 'reshoring' (Hartman, et al. 2017; Raja, 2017), especially because most existing literature focuses on offshoring and global location decisions, which is a distinctly different concept (Benstead, Stevenson, & Hendry, 2017). Although some research has been done on reshoring, no academic literature is available about the influence of Industry 4.0 on the drivers of reshoring. Besides, key drivers for reshoring have been investigated, however some related aspects are only covered by a little number of exploratory qualitative research (Barbieri et al., 2018). Therefore the understanding of the concept is still limited. Industry 4.0 is expected to be one of the aspects to have a salient impact on the reshoring drivers. Moreover many researchers tried to determine the key drivers for reshoring theoretically (e.g. McIvor, 2009). Established theories such as transaction cost economics were used to be able to explain sourcing failures (Handley and Benton, 2013). Despite the fact that some reshoring drivers were found, these drivers have not yet been fully extended from the scope of Industry 4.0. Because the fourth industrial revolution is expected to have such a large influence on today's business practice, and because Industry 4.0 influences reshoring decisions, it is academically relevant to deep-dive into the drivers for reshoring and specially to contextualize this within the situation of Industry 4.0.

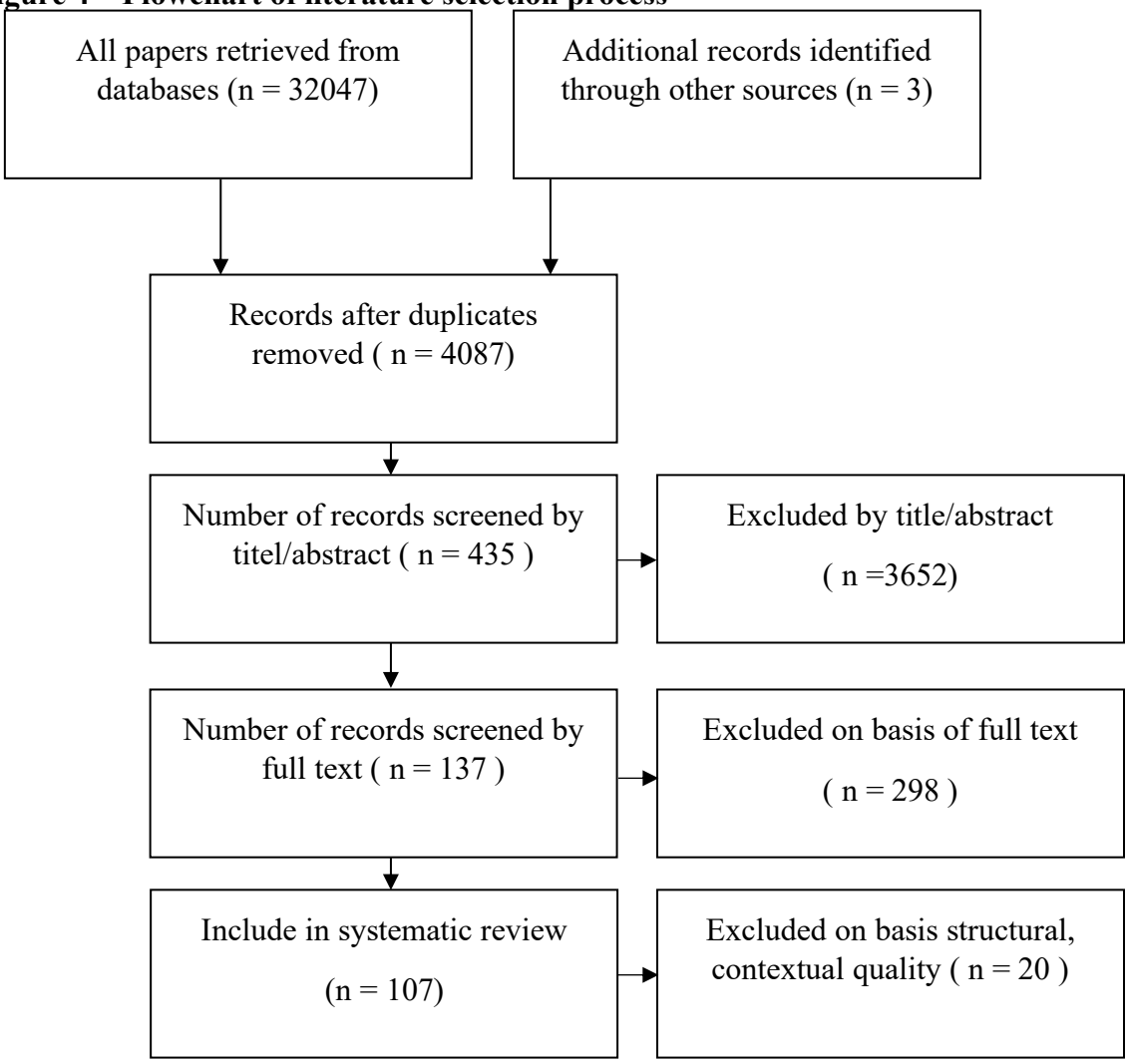
2. Literature review

2.1. Search process and the literature selection

The search process provides a flowchart of the literature selection and gives an insight what literature exists concerning Industry 4.0 and its influence on reshoring decisions. Since the research focusses within the manufacturing it is important to understand how Industry 4.0 can be implemented for certain manufacturing techniques. When there is a clear understanding of Industry 4.0 in the manufacturing industry, the existing literature of reshoring has to be researched. When both phenomena are clear, inclusion criteria will be added to investigate a possible relationship between Industry 4.0 and reshoring. This has been done by adding each driver separately from the reshoring framework (Benstead, Stevenson & Hendry, 2017) to the keyword Industry 4.0. A search criteria for example was 'Industry 4.0' and 'labour cost reduction' (driver 2.1). The results of these are presented in chapter 2.4.1 to 2.4.4.

During the selection process for the literature multiple keywords have been used. These were especially industry 4.0 and reshoring. Since multiple words have the same meaning the following keywords; smart industry, back-shoring, backsourcing, back-manufacturing have been used as well. Thus, each driver of the framework has been added to Industry 4.0 as inclusion criteria in order to find a possible connection between Industry 4.0. Besides Google for the search of articles and additional records, the databases Scopus, Web of Science and Google Scholar have been used.

Figure 4 – Flowchart of literature selection process



2.2 Industry 4.0

Advanced digitalization within companies and by combining future-oriented technologies in the field of smart objects and new technologies with the internet have resulted in the fourth industrial revolution (Lasi et al., 2014). These developments have led to the prediction of experts whereby they mention that Industry 4.0 could lead to the relocation of activities that were once offshored (Blanchet, Thieulloy, Rinn & Thaden, 2014, p.22; Fraunhofer ISI, 2015, p.10), mostly due to cost-effectiveness (Handley and Benton, 2013). Making Industry 4.0 an important factor that could influence reshoring. The term Industry 4.0 made its debut in 2011 when it was first coined by Henning Kagermann, Wolf-Dieter Lukas and Wolfgang Wahlster and published in 2011 at the Hannover Messe (Kagermann, Lukas and Wahlster, 2011). However, the meaning of Industry 4.0 was initially rather vague than clear (Bauernhansl, Ten Hompel, & Vogel-Heuser, 2014). The term was adopted by the German Government as a high-tech strategy that promoted especially the computerization of manufacturing (BMBF, 2016). The number 4.0 is intended to relate to prior industrial revolutions and to underline that the change trough Industry 4.0 would have the same meaning. However the term Industry 4.0 is also criticized due to "the fact that for the first time an industrial revolution is proclaimed even before it took place" (Drath, 2015. p.3). This point of view is backed up by the argument that the current revolution is rather predicted than observed after as it was the case with previous industrial revolutions (Dratch, 2015 and Horch, 2014).

Industry 4.0 in the manufacturing industry follows the trend whereby crucial factors like responsiveness to changing customer demand, efficiency, agility and the focus on product quality and regulatory compliance decides the success of a firm (Brousell, Moad and Tate, 2014). There is an increasing demand for digitalization and automation to comply with these success factors (Rashid and Tjahjon, 2016). This, and an enhanced level of connectivity in a manufacturing environment are only possible when there is a seamless integration of production machinery and enterprise systems. To be able to meet the crucial factors and to digitize as a manufacturing company, processes need to act autonomously and in an intelligent way (Genovese et al. 2014, Bechtold et al. 2014). Shortage of qualified workers, more requirements for product individualization, and increasing competitive pressure in combination of an unstable demand from customers are also major drivers for Industry 4.0 (Macurova, Ludvik and Zwakova, 2017). Recent research (Koch et al. 2014) estimates that the share of investments in Industry 4.0 applications will be for more than 50% of planned capital investments. IT is increasingly becoming an integral part

of these investments. Products and machines are coupled in a cloud with the help of integrated software, sensors and processors. From without the cloud, machine and product data is stored and analyzed in order to improve its performance and functionality (Porter & Heppelman, 2014).

Due to these rapid developments a consortium 'smart industry'[2] was formed in 2014 by FME-CWM (business association for the technology industry in the Netherlands), TNO (Dutch organization for applied scientific research), VNO-NCW (Dutch employers' organization), the Ministry of Economic Affairs (EZ) and the Dutch Chamber of Commerce to launch the initiative for the Smart Industry program (Smetsers, 2016). The consortium's goal was to promote and to raise awareness for Industry 4.0 at companies. It therefore used the following definition for the fourth industrial revolution: "Smart Industry uses ICT and new technologies - such as 3D printing and robotics – smart by making products and machines interconnected and smart controlled. This does not only happen within one company, but also between companies and between companies and customers. Products, processes and services become smarter". Other often mentioned definitions used for Industry 4.0 in the literature were "Industry 4.0 focuses on the establishment of intelligent products and production processes" (Brettel, Friederichsen, Keller, & Rosenberg, 2014, p.38). And "Industry 4.0 describes the organization of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the 'smart' factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions based on self-organisation mechanisms" (Smit, Kreutzer, Moeller, & Carlberg, 2016).

One of the reasons for launch of the Duch consortium was the fact that the phenomenon Industry 4.0 was rather unknown by Small and Medium Enterprises (SME), only 15% of the companies mentioned ever hearing about it (Smetsers, 2016). From the 77% of SME's that didn't knew about Industry 4.0, 30% saw it as an opportunity, 23% as well as threat and opportunity and only 1% saw it just as a threat (Smetsers, 2016). From the SME's that indicated to be familiar with Industry 4.0, 58% saw opportunities. This research (Smetsers, 2016) also mentioned that this fact is striking since a quarter of the people who initially indicated not to be familiar with the term, after explanation indeed saw opportunities for its own company.

While the term of Industry 4.0, Smart Industry or Advanced Manufacturing are not very known, it is exactly the unfamiliarity why it is not sure for manufacturing companies what this

[2] Also referred to as Industry 4.0.

phenomenon encompasses and what it will bring. This fact stresses the importance of increasing the knowledge and understanding of Industry 4.0. Especially as through Industry 4.0 a positive change of operational performances is expected even as a change in business models, products and services (Kagermann, Helbig & Wahlster, 2013). To get a better idea of what Industry 4.0 exactly is and to get a better understanding of the risks and its influences on reshoring, the basics needed to be understood and learned. By forming a good understanding of the enablers of Industry 4.0 it is subsequently easier to research its influences on reshoring.

2.2.1 Major manufacturing techniques of Industry 4.0

Since this paper focusses primarily on reshoring decisions within the manufacturing industry, it is of great importance to review what manufacturing concepts there are in Industry 4.0. Subsequently these techniques can be further identified at companies during the execution of the research. For example certain manufacturing techniques could lead to reshoring decisions and some not. Industry 4.0 has multiple characteristics in which it distinguishes itself from the other industrial revolutions. The manufacturing can be divided into three major advanced manufacturing concepts, namely IoT manufacturing, intelligent manufacturing and cloud manufacturing (Zhong et al., 2017) .

2.2.1.1 Internet of Things manufacturing concept

Some researchers argue that Industry 4.0 is "often understood as the application of the generic concept of cyber physical systems (CPS) and Internet-of Things (IoT)" (Drath & Horch, 2014, p.56). Remarkable is the cyber-physical aspect that consists of making use of the internet of things within industrial practices. These aspects of cyber-physical systems (CPS) are also defined as transformative technologies for managing interconnected systems between its physical assets and computational capabilities (Baheti & Gill, 2011). CPS and IoT can be also seen as merging the virtual with the real word (Schlaepfer & Koch, 2015). Hence CPS and IoT therefore play a major role. In short IoT manufacturing is an advanced method whereby typical production resources are being transformed into smart manufacturing objects. These smart manufacturing objects are able to interconnect, sense and even interact with each other to automatically and adaptively carry out manufacturing logics (Zhong et al. 2013). In IoT-manufacturing setups human-to-machine, human-to-human and machine-to-machine connections are installed for intelligent perception (Tao

et al., 2014). With these interactions efficient sharing of resources and on-demand use can be established through the application of IoT technologies in manufacturing.

"IoT is considered to be a modern manufacturing concept under Industry 4.0 and has adopted recent advances, such as cutting-edge information technology (IT) infrastructure for data acquisition and sharing, which greatly influence the performance of a manufacturing system" (Zhong et al., 2017. p.618). A good example of adapting IoT is by integrating this technology into garments and accessories. The global trend for smart garments already indicate that these techniques will be utilized on a much larger scale in the near future (European Commission, 2016).

2.1.1.2 Intelligent manufacturing concept

Intelligent manufacturing is also known as the smart manufacturing principle that was first coined at the Department of Energy (DoE) and the National Institute of Standards and Technology (NIST) in the United States (Thoben, Wiesner and Wuest, 2017). Intelligent manufacturing includes multiple technologies, including but not limited to: CPS, IoT, robotics/automation, big data analytics, and cloud computing (Federov et al., 2015). This makes data intensive application of information technology possible at the shop floor level and above to enable intelligent, efficient, and responsive operations. One clear definition of intelligent manufacturing processes is that these have "the ability to self-regulate and/or self-control to manufacture the product within the design specifications" (Kumar, 2016). Especially artificial intelligence that has reasoning, learning and acting possibilities, play a major role in intelligent manufacturing. By incorporating artificial intelligence, human involvement in an intelligent manufacturing concept can be minimized as much as possible (Zhong et al., 2017). This is also one of the reasons why intelligent manufacturing concepts are seen as way to change textile production through flexibility in manufacturing and production process integration (Stylios, 1996).

2.1.1.3 Cloud based manufacturing

Cloud based manufacturing is an advanced manufacturing method which is being supported by the IoT, cloud computing, virtualization and service-oriented technologies. These technologies transform manufacturing resources into services that can be comprehensively shared and circulated (Zhang et al., 2010; Xu, 2012). This networked manufacturing concept uses on-demand access to a shared collection of diverse and distributed manufacturing resources. These resources then form

temporary, reconfigurable production lines that will reduce product lifecycle costs and enhance efficiency that will allow for optimal resource allocation in response to variable-demand customer generated tasking (Wu et al. 2013). Production capacities and resources are being intelligently managed by one manufacturing system. The manufacturing cloud encompasses with design, simulation, manufacturing, testing and maintenance the entire life cycle of a product (Zhong et al., 2017). This technique is also increasingly being more looked into to ensure business survival in the textile industry (Damodaram and Racvindranath, 2010).

Table 1

Comparison of Industry 4.0 manufacturing concepts

Concepts	Major characteristics	Supporting technologies
IoT manufacturing	▪ Auto-ID technology-based smart manufacturing system ▪ Real-time data collection ▪ Real-time visibility and traceability of production processes ▪ Real-time manufacturing decision-making	▪ IoT ▪ Wireless production ▪ BDA ▪ Cloud computing
Intelligent manufacturing	▪ AI-based smart decision making ▪ Advanced automotive production ▪ Adaptive and flexible manufacturing systems	▪ Big data processing ▪ Advanced robotics ▪ Industrial connectivity services ▪ Last-generation sensors
Cloud manufacturing	▪ Manufacturing service distribution and sharing ▪ Intelligent capability management ▪ Manufacturing cloud service management	▪ Cloud computing ▪ IoT ▪ Virtualization method ▪ Service-oriented technology

Source: Excerpt from table Zhong et al., 2017

2.3 Current literature about reshoring

Reshoring is a development that already took place before any literature wrote about the concept (Fratocchi et al., 2013). As it was with Industry 4.0, also Germany was one of the first countries starting to research reshoring. For this reason, a large sum of the literature about reshoring finds its origins in Germany (Fratocchi et al., 2013).

One of the disadvantages is the polysemy that exists around the word reshoring. Since 2011 terms such as back-reshoring, backsourcing, backshoring, inshoring, onshoring are used to describe the same phenomenon. However the wide diversity of terms does not stop here since the definition of reshoring depends on the writer. For this very reason, this literature review pans out the variety of the definitions of reshoring in order to point out why the framework of Benstead, Stevenson and Hendry (2017) was chosen.

Reshoring is not always seen as bringing back the production, but also as the preservation of the production (Canham and Hamilton, 2013). Canham and Hamilton (2013) state that companies that choose to stay at their location, make the same considerations as companies that resent. However, this research will adopt the theoretical framework of Benstead, Stevenson and Hendry (2017) about reshoring.

2.3.1 Nearshoring

From the framework it becomes evident that there is a certain degree of reshoring (Benstead, Stevenson and Hendry, 2017). The concept of the reshoring framework can also be applied if nearshoring is the case. Nearshoring is applicable when a firm decides to find manufacturing locations closer to its headquarters to achieve a compromise between advantages of onshore and offshore locations. However an important aspect that needs to be stressed out is the fact that reshoring is only the case when a tipping point for relocation has been achieved. Benstead, Stevenson and Henry (2017, p.97) state ‘an important aspect of operationalizing the reshoring decision concerns timing, i.e. when to trigger the reversal process’.

An increasing number of export companies are nearshoring to eastern Europe from their existing activities in Asia (Kinkel, 2012). This is due to their increasingly gained attractiveness. Thanks to (re)concentrating their production activities the companies were able to benefit of higher capacity utilization. For example many countries in eastern Europe experience now nearshoring activities from companies (Barbieri et al. 2018).

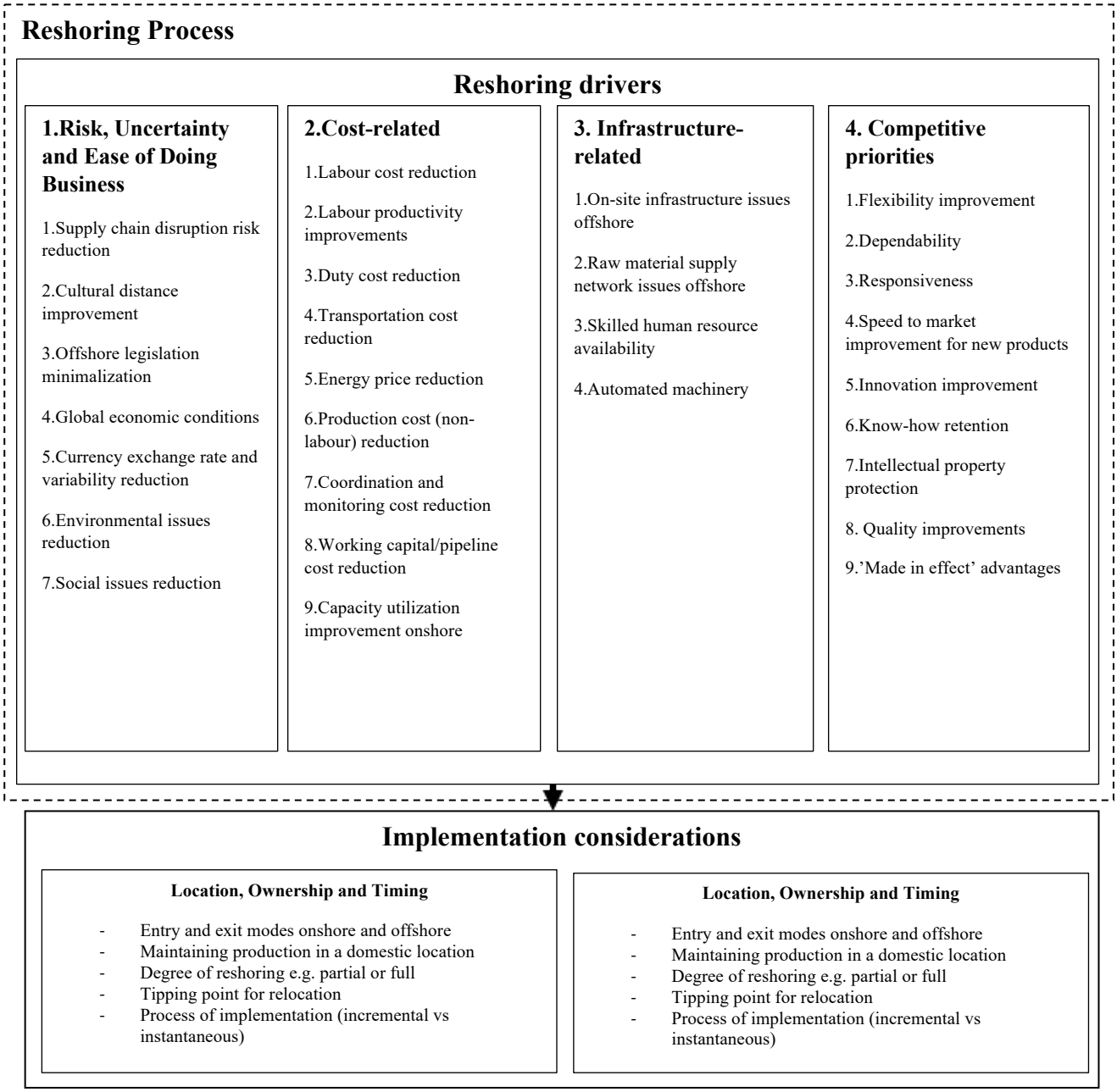
The fact that since 2006 a lot of European locations have experienced reshoring trends can be explained because reshoring cases from Eastern European countries have been partially determined by the EU enlargements in 2004 and 2006. These enlargements facilitated location, ownership and internalization advantages (Dunning, 1995).

Multiple industrial sectors in Germany have been covered by research, but existing research stresses the need of more empirical evidence from other branches and countries (Kinkel, 2012). Therefore this paper aims to look forward and to systemically integrate scenarios of nearshoring of other companies as one of "the future development of the most influential environmental factors in future research frameworks for global production decisions and value chains" (Kinkel, 2012).

2.3.2 The Reshoring Framework

Reshoring itself underlines the relocation of a company's activities from offshore locations back to the previous home country or a neighboring country (De Backer et al.,2016; and Foerstl et al., 2016). There are two separate branches to reshoring; One is relocating to the home country and the other one is to relocate to a neighboring country (nearshoring). Nearshoring is also defined as "outsourcing work to companies with the economic benefits of an offshore location, but a closer cultural, linguistic and geographic fit with the user organization" (Bradbury, 2015). The concept of reshoring is not concerned with ownership of the activities or closure of previously offshored work (De Backer et al., 2016). Reshoring drivers are a key factor within the reshoring decision process, these factors motivate a company to reshore and subsequently to reverse the prior location decision. The framework identified factors that influence certain reshoring drivers in the reshoring process. These drivers in itself contribute to the implementation consideration, including factors such as; location, ownership and timing, but also the operations and supply chain development phase. Within the framework the drivers of reshoring decisions are split into four categories (see figure 4). All categories are subsequently divided into 20 drivers. These 20 drivers have become evident from a one case study. These categories are: (1) Risk, uncertainty and ease of doings business. (2) Cost-related drivers. (3) Infrastructure-related drivers. (4) competitive priorities (as shown in Figure 4). Benstead, Stevenson and Hendry (2017) did an extensive research on all of the drivers and based on their research this paper will further investigate if and how Industry 4.0 influences these categories that are followed by their drivers.

Figure 4 - Refined Conceptual Framework of the Reshoring Process



Source: Benstead, Stevenson & Hendry, 2017

2.4. Which enablers of Industry 4.0 influence which reshoring drivers

The amount of research about Industry 4.0 and its influence on reshoring is scarce. Therefore, and since recent research suggests that "there might be an intimate relationship between reshoring and the various forms of technological innovations applied to manufacturing – which has become popularly labeled as "Industry 4.0" (Barbieri et al., 2018 p.79), this paper tends to do a preliminary study of what factors of Industry 4.0 could drive reshoring decisions.

Some previous research shows that there could be a positive correlation between Industry 4.0 and reshoring. Focal point however is to find out on which factors Industry 4.0 could have any influence. From there on it is of great importance to further examine each of the drivers separately that are possibly influenced by Industry 4.0. First pointers were earlier research whereby it has been found that companies that reshore tend to have a higher degree of technological innovation in comparison with companies that offshore and the same is applicable for companies that remain domestic (Stentoft et al., 2016).

Another factor that drives companies to reshore are the fact that customers are prone to pay a premium price for goods manufactured in their home country (Grappi et al., 2015).

Also at a political and policy level there is an ongoing debate whether Industry 4.0 will result in the increase or loss of jobs. For example, whereby the president of the United States of America wants to increase the number of jobs by bringing the manufacturing industry back to the U.S.A (Murphy, 2017). Nonetheless the fourth industrial revolution will require a different and most likely higher and a sharper kind of worker skills. Governments are therefore enforcing policies in order to support the digital transformations of manufacturing and most probably favoring the repatriation of production activities and the employment of high skilled workers.

In the last decades cheaper manufacturing in emerging markets caused an international fragmentation of production, with trade in intermediate goods accounting for over 60 per cent of world exports (UNCTAD, 2013, p. 122). However the increasing availability and lower cost of industrial robotic systems will continuously increase the impact upon the economics of location decisions within the manufacturing industry, especially when costs like labour and other costs are continuously rising in many emerging economies (World Trade Organisation, 2016). The result therefore could possibly be the reshoring of activities to the advanced economies (Albertoni et al., 2015). Although the scale of reshoring decisions is thus far still limited (Oldenski, 2015).

While the research about Industry 4.0 and reshoring is limited it gives some pointers to which drivers are influenced. Literature shows that Industry 4.0 is a technological disruptive innovation which increases automation and lowers the need for low cost labour. Therefore it can be argued that the cost-related drivers of the reshoring framework are influenced. Further on Industry 4.0 is encouraged by governments, as wells as on European level (Davies, 2015). Facilitating Industry 4.0 and thus lowering the risk and uncertainty for companies. Most probably therefore the reshoring drivers of risk, uncertainty and ease of doing business are also affected.

Lastly, the driver of competitive priorities of the framework is arguably influenced by Industry 4.0 since it contributes to a better product quality and system reliability (Lee, Bagheri, Kao, 2015). Additionally, as mentioned earlier, Industry 4.0 can also facilitate the added value of 'made in' brands, subsequently making reshoring an interesting development for companies (Canham and Hamilton, 2013).

2.4.1. Industry 4.0 and Risk, uncertainty and ease of doing business

As mentioned in chapter 2.1 and in order to get an answer on the research question each driver of the reshoring framework and its possible connection to Industry 4.0 will be researched. As shown in Figure 4, where the reshoring process is shown, there are multiple categories of drivers that influence reshoring decisions. In this and the following subchapters (chapter 2.4.1 – 2.4.4), it will be discussed whether from existing literature it becomes evident if Industry 4.0 influences this framework. In other words, which and how categories and its corresponding drivers for reshoring decisions of the framework are influenced by Industry 4.0; and therefore will be taken into consideration during this research.

The first category is *Risk, uncertainty and ease of doing business*. The drivers behind this category (labeled 1.1 – 1.7 in Figure 4) are embedded within the goal to reduce the exposure to risk, uncertainty through reshoring and subsequently to have the same or a more efficient operation in the domestic location of the firm (Benstead, Stevenson and Hendry, 2017).

Driver 1.1, 1.2, 1.3, 1.4, 1.6 and 1.7 are taken into consideration during this research for the following reasons:

- Driver 1.1: There can be a drive to reduce the risk of supply chain disruption and therefore to reshore (Huq et al, 2016). Industry 4.0 facilitates lower inventory levels and the supply

chain for raw materials. It is yet unsure how this driver would be influenced, but it could be influenced especially since "technology diffusion enables new business models and the ease of doing business, ultimately fostering economic growth" (Berger, 2017, p.13). Making it also possible that this driver becomes relevant as Industry 4.0 minimizes the supply chain disruption. More and more manufacturers want to lower inventory and move to more just-in-time deliveries (Flynn et al. 1997). Mass customization is, for example, a trend that heavily benefits from a good supply chain management (Benstead, Stevenson and Hendry, 2017). Companies balance their supply chain strategy on the total risk-benefit-balance rather than only on cost analysis (Backhouse and Moradlou, 2016). For the mass-customization it is even not advisable for companies to have overseas production (Wohlers, 2011). Hence there it is a must to increase domestic manufacturing and employment. Because of pioneering customers it is thus important to reshore (Tavasoli, 201). A high level of synchronization between organizations and information sharing is paramount to ensure that customers' needs can be satisfied (Brettel et al, 2014). Industry 4.0 can thus result in high agility for the inventory levels and lead times within the value chain will decrease (Brettel et al., 2014).

- Driver 1.2: Another factor that could be influenced and for reshoring needed to be overcome was cultural distance **(**Tate, 2014 and Gray et al. 2013). Physical and cultural distance could even reduce innovation and even contribute to the loss of tacit knowledge (Caniato et al., 2013). Cultural distances make it also more challenging to develop the needed levels of communication (Taylor, 1911), trustful and long-term relationships between firms and their suppliers (Bernardes, 2010). Besides, the increasing acceleration of digitalization reduces obstacles in communication and fosters an even stronger exchange of information (Berger, 2017).
- Driver 1.3 and 1.4: Global economic conditions (driver 1.4) are also a reason why firms would reshore. For example, the current president of the United States has imposed tariffs so that more products can be built in the United States of America. President Trump has said that "there is an easy solution where there would be ZERO tax, and indeed a tax incentive. Make your products in the United States instead of China. Start building new plants now" (Trump, 2018). Also other policies as incentives have been taken into effect to increase domestic innovation (Westmore, 2014). These factors are therefore likely to

facilitate the implementation of Industry 4.0. These incentives for innovation could also be legislation minimalization (driver 1.3) for companies. While this is a main driver to reshore, legislation is also been enforced by the European Parliament by developing an Action Plan for Industry 4.0 (Smit el al., 2016). Creating therefore in the EU a more friendly environment for certain companies to reshore and to invest in solutions related to Industry 4.0.

- Driver 1.6 and 1.7: Industry 4.0 also expands the opportunities of sustainable manufacturing. Research has for example shown that the allocation of resources can be realized in a more efficient way by using intelligent cross-linked models. Besides environmental issues, there is also value creation by Industry 4.0 for economic and social issues (Stock & Seliger, 2016). Whereby intrinsic and extrinsic motivations of employees can be influenced.

Driver 1.5 is the only factor that has no connection to Industry 4.0:

- Driver 1.5: Currency and exchange rate and variability reduction has been identified as the most significant driver for this category (Benstead, Stevenson and Hendry 2017; Martinez-Mora & Merino, 2014; Pearce, 2014; Gylling et al. 2015). However, this factor has not been found relevant with respect to Industry 4.0.

2.4.2 Industry 4.0 and Cost-related drivers

The second category (see Figure 4) is called *Cost-related drivers*. It consists of nine drivers, labeled 2.1 – 2.9, which are all linked to reshoring and Industry 4.0 influences these links in the following ways:

- Driver 2.1: Cost savings are an important driver for reshoring (Zhai, Sun and Zhang, 2016). As a factor it is even the most important motivation for reshoring in the framework. Reshoring can also be seen from a cost-perspective point of view as "bringing back to the US of manufacturing lost to emerging markets as US firms sought to compete against low-cost imports in the last decade" (Burns, 2016). Reshoring savings in (labour) costs are also an important aspect (Pearce, 2014). As previously mentioned labour costs in China

increased enormously. Also in other low-cost countries the cost of labor is continuously increasing (Fishman, 2012 and Anon, 2012).

- Driver 2.2: Besides there is a continuously improving ratio of labor output and productivity per labor dollar in the United States, thus therefore making it increasingly more interesting for U.S. firms to reshore (Fishman, 2012). This perspective is also backed by the Boston Consulting Group (2014), they found that between 2004 and 2014 the wages in China multiplied four times as fast in comparison to the productiveness of the workers. While Industry 4.0 requires high skilled workers, it decreases the number of workers due to automation. Subsequently firms could reshore since the advantages of low-cost countries would decrease by time.
- Driver 2.3: The increasing cost of labor in emerging markets, increased transportation and duty costs and high oil prices made homebased locations of manufacturers more attractive (Tate, 2014). The increasing awareness of global supply chain risk have accumulated to make homebased manufacturing for U.S. companies also a more attractive location (Tate, 2014). Also customers satisfaction improved due to companies reducing the length of the supply chain and therefore also reducing the risk (Nelson, Moody and Stegner, 2001).
- Driver 2.4: Offshoring manufacturing became decreasingly interesting due to increasing transportation costs and time. From the perspective of energy and sustainability a "sustainable-oriented decentralized organization in a smart factory focuses on the efficient allocation of products, materials, energy and water" (Stock and Seliger, 2016, p.540). The holistic resource efficiency is therefore being described as one of the primary advantages of Industry 4.0.
- Driver 2.5: Also energy is one of the costs related drivers that contribute to reshoring (Bossche et al. 2014). Electricity costs can be 40 to 70 percent lower in the U.S. than in Japan. Since Industry 4.0 will bring high efficiency and flexibility as well as lower energy consumption (Wang et al, 2016), the effect of Industry 4.0 on this driver is most likely. Especially since the total amount of employees needed lowers, while the total amount of automated inter-connected machines increases. Therefore it is more likely that the total amount of energy consumption will also increase, making this driver also relevant.
- Driver 2.6 and 2.7: All of the costs above mainly involve the labour, transport, duty and production costs (driver 2.6). However offshore manufacturing locations do also need

coordination and monitoring (driver 2.7) in order to be successful. Like the company in the case study from Benstead, Stevensen and Hendry (2017) the management team had to frequently travel to China to implement systems and to train employees. Earlier research has already shown that companies that feature intelligent logistics systems, thus Industry 4.0, facilitate enormously the control and management of manufacturing systems over the internet in real time (Mendes, Osaki & Da Costa, 2018).

- Driver 2.8: Working capital and pipeline costs can be higher due to high inventories in transit or distribution centers (Tate et al., 2014). Industry 4.0 enables that "manufacturers can lower their inventory costs and reduce the amount of capital required" (Löffler & Tschiesner, p6, 2013), making this driver also relevant to the research.
- Driver 2.9: The capacity utilization can be important to lower overhead related costs, making reshoring a great advantage (Kinkel and Zanker, 2013). Industry 4.0 can increase capacity utilization since it facilitates domestic production and is especially relevant for companies that have retained domestic presence (Benstead, Stevenson and Hendry, 2017). Making it therefore the driver of increasing capacity utilization also relevant (Kessler & Brüll, 2015).

2.4.3 Industry 4.0 and infrastructure related drivers

The third category, shown in Figure 4, is named *Infrastructure related drivers*. The corresponding drivers are numbered 3.1 – 3.4. The case study of Benstead, Stevenson and Hendry (2017) on reshoring showed little to none significant drivers related to infrastructure considerations. While these drivers are not seen as direct driven, they do facilitate reshoring. More research is needed concerning the effectiveness of investments in infrastructure and its impact on reshoring decisions (Babieri et al., 2018).

Driver 3.1 will be eliminated from this research as this first driver is on-site infrastructure issues offshore, while these have an effect on reshoring decisions, it is unlikely that these are impacted by Industry 4.0. Especially because companies have most likely already sorted out infrastructural issues in their homebased country.

Driver 3.2, 3.3 and 3.4 are linked to reshoring and Industry 4.0 could influence these links for the following reasons:

- Driver 3.2: Studies refer to the Industrial Internet of Things (IIoT) when industrial machines are connected to the enterprise cloud storage area for data storage and data retrieval. Industry 4.0, along with IIoT, could cause a large revolution in the management of supply chains (Jayaram, 2016). Combining Industry 4.0 and reshoring could result in a faster and more seamless supply of raw materials (driver 3.2) in comparison with global supply chains (Caniato et al. 2013). Especially as reshoring can extensively improve speed, simplicity and flexibility to enable a leaner and more responsive supply chains (Chicksand et al., 2012). The infrastructure perspective on reshoring from an interactive network approach has also been viewed and showed that reshoring affects the nature and the interaction of local resources (Lavissiere, Mandjak and Fedi, 2016).
- Driver 3.3: Industry 4.0 focusses on digitalization processes and would therefore also need new technical skills (Koch & Schlaepfer, 2015). The implementation of new process-dependent systems that make greater use of the latest technology could therefore prove a challenge for existing employees. Making the driver of skilled human resource availability of great importance.
- Driver 3.4: Since Industry 4.0 also uses automated machinery, it is not unimaginable that "Industry 4.0 and the unstoppable rise of automation (driver 3.4) is redefining manufacturing processes once and for all" (Szweczyk, Zieliński & Kaliczyńsja, 2018). Therefore, this driver (automated machinery) should also be taken into account.

2.4.4 Industry 4.0 and Competitive Priorities

The last category shown in Figure 4 is named *Competitive Priorities*. Nine drivers are part of this category, labeled as driver 4.1 – 4.9. All these drivers are taken into consideration during this research for the following reasons:

- Driver 4.1, 4.2, 4.3 and 4.4: The most prominent and evident in the case of Benstead. Stevenson and Hendry (2017) were the increased flexibility improvements (driver 4.1) thanks to the reshoring decision. This view has been supported by research with a data set of 1484 German manufacturing companies (Kinkel, 2012). Changing market needs gain increasingly momentum and dependable, more predictable domestic lead times and on time delivery become more important (driver 4.2). The amount of responsivity of a firm (driver 4.3) affects the reshoring decisions, because the firm is more able to compete on speed due

to more proximity to the customer (Pearce, 2014). A reduction in time-to-market (driver 4.4) of personalized products require shorter and leaner supply chains (Vyass et al., 2016). Speed to market improvement for new products are also one of the factors of the conceptual framework (Pearce, 2014). In order to keep up with the competitor's speed of innovations it is essential for a company to radically compress its product development process. Industry 4.0 could influence the reshoring framework as this concept, for example new tool machining concepts, can help to minimize the length of time to develop products (Brecher et al., 2010).

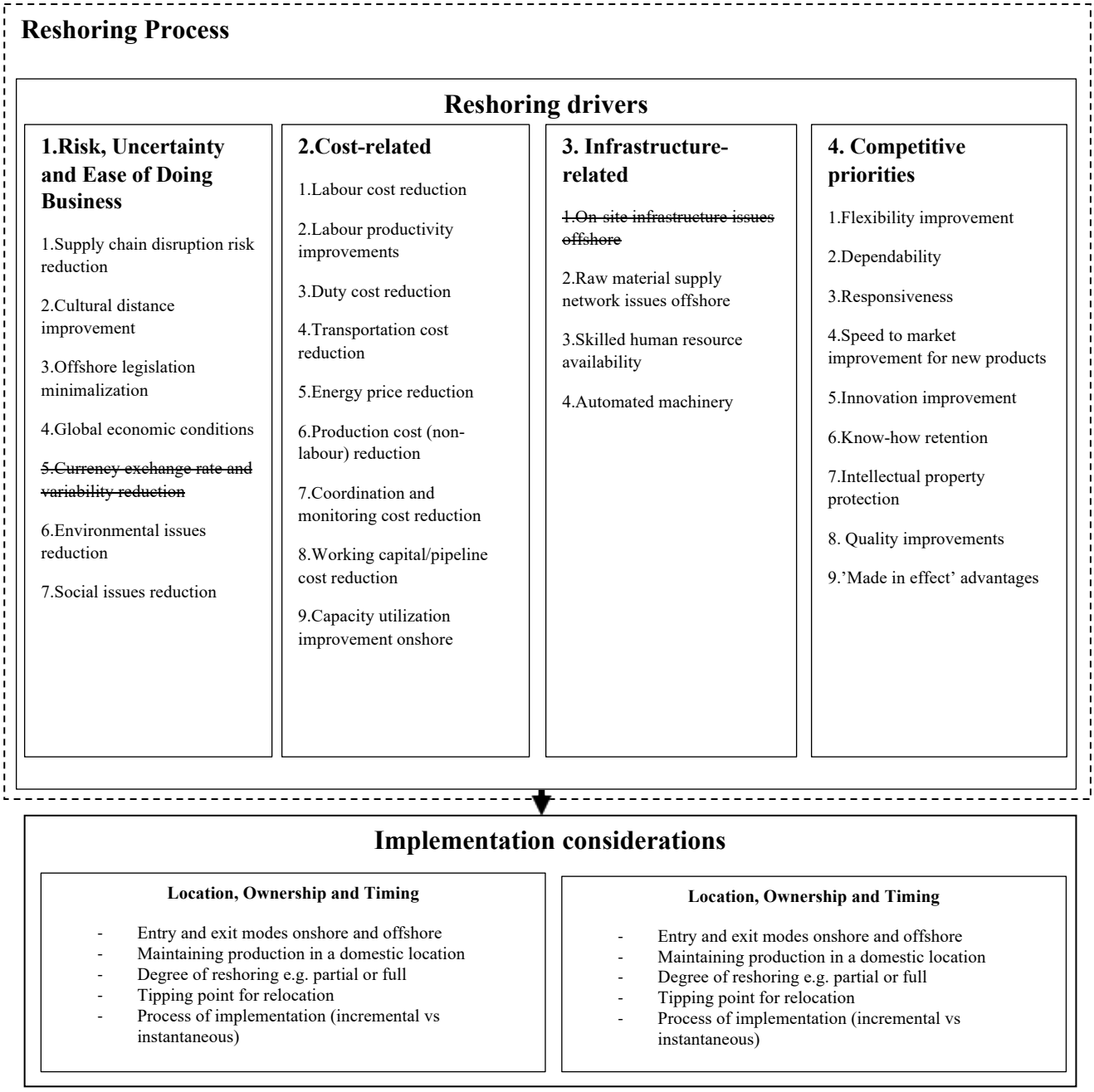
- Driver 4.5: Industry 4.0 means the basis for the adoption of innovations and new production processes (Rüßmann et al., 2015). Therefore Industry 4.0 is an important driver of innovation improvement.
- Driver 4.6 and 4.7: Almost no research could be found about knowledge retention (driver 4.6) and intellectual property protection (driver 4.7) due to Industry 4.0. However, it is imaginable that is easier to retain know-how and intellectual property, with regard to Industry 4.0, as it is closer to home. For that reason these drivers will also be included in the methods part. However it is possible that there is not an influence of Industry 4.0 on this reshoring driver.
- Driver 4.8: Reshoring of firms in the U.K. were more driven by quality and outweighed the cost-related drivers (Groom and Poweley, 2014). Quality improvements and its impact on reshoring was researched and a positive correlation was found (Uluskan et al., 2016). Industry 4.0 will improve product quality and decrease time-to market (Brettel, 2014), making it also a factor that could influence this category.
- Driver 4.8: Except for quality, reshoring can also facilitate the added value of 'made in' brands. The 'made in' effect is especially important within the garments industry (Barbieri et al. 2018). Therefore, it is expected that the opportunities of Industry 4.0 will also affect the reshoring decisions in the textile industry.

2.5 Summarizing the literature review

The literature review showed that most reshoring drivers are likely to be influenced by Industry 4.0. Literature shows that Industry 4.0 could have an influence on the drivers of (i) risk, uncertainty and ease of doing business, (ii) cost related drivers, (iii) competitive priorities and Infrastructure-related drivers (iv). However some drivers of these categories seem less relevant and some of them are therefore not likely to be affected by Industry 4.0.

Following the subquestions from chapter 1.4, it can be concluded that the terms and conditions from the literature are very similar to that from the Dutch consortium of smart industry. Since this research focusses on Dutch SME's, the following definition of smart industry or Industry 4.0 will be used. The key set of terms and conditions for Industry 4.0 are therefore; ICT and new technologies used to make smart by making products and machines interconnected and smart controlled. This is not only necessary within one company, but could also very well among companies and between companies and customers. Therefore, overall, the products, processes and services become smarter.

Figure 5 - Refined Conceptual Framework of the Reshoring Process with Possible Links to Industry 4.0



Source: Benstead, Stevenson & Hendry, 2017

3. Methods

3.1 Qualitative research

There a is a quantitative and qualitative way for doing research. Firstly, a problem can be quantified through the use of generating numerical data or data that was transformed into statistics. This approach uses measurable data to formulate facts in order to uncover patterns and is therefore called quantitative research. This is rather used to quantify attitudes, behaviors, opinions and other defined variables. The goal of quantitative research is to confirm hypotheses about a specific phenomenon and to generalize the results from the study sample to the general population (or specific groups). However, this research aims at understanding and to find possible underlying reasons of Industry 4.0 and reshoring. Therefore qualitative research is more appropriate. Qualitative research could provide insights and new theories of a phenomenon and could even develop a theory for potential future quantitative research.

Thanks to a step-by-step model the systematic analysis of data of qualitative research is possible (Boeije, 2014). This method allows to develop a theory and to make sense of certain phenomena like Industry 4.0 and reshoring. Qualitative research is especially suitable to describe and clarify new phenomena (Boeije, 2014). The phenomenon of Industry 4.0 and reshoring have been observed, but however not yet been fully understood (Algozzine and Hancock, 2006). Qualitative research is therefore the best approach to research Industry 4.0 and its possible influence on reshoring in the manufacturing industry.

The research question is being researched by the means of the flexible methods that allows contact with the involved participants to an extent that is necessary to understand what is going on in practice. Flexible methods encompass certain decisions that are not taken in advance but rather during the investigation. The qualitative research design has therefore a developing nature and the methods for data collection that are used allow for a close approach with the research field. This flexible approach also applies to the analysis. Because of this approach one does not know in advance which data will be generated and what the framework of the analysis will look like. The results and the focus of the analysis will slowly develop during the research process. Research is collected through semi-structured interviews.

The cases will be analyzed in-depth in order to provide an objective view on what the influences could be of Industry 4.0 on the motives to reshore. Eight companies and organizations

involved with reshoring and Industry 4.0 are being interviewed. These companies are mainly Dutch manufacturing companies that have already reshored or want to reshore. Companies within the textile industry were approached, whereby size was not taken into account. Additionally, companies that are nearshoring are included, as described in paragraph 2.3.1 nearshoring resembles to the phenomenon of reshoring. Research is conducted by studying primary data with interviews of the parties concerned, therefore the findings will primarily consist of data from the interviews.

3.2 Constraints and Criteria

For the sampling criteria the companies that will be interviewed have to be at the intersection of Industry 4.0 and reshoring in the textile industry. These companies will have similar contingency factors in terms of age, size, type of industry, revenue in order to control for these factors. A sample size of eight companies will be used for this study. This sample size will allow this research to investigate companies within the textile industry however with marginally different sizes and structures.

The textiles, clothing and footwear (TCF) industry has been especially chosen due to the fact these businesses need to adopt very quick to the changing demand of customers. For example the fashion industry has changed its offering from two (Spring/Summer and Fall/Winter) up to 52 micro seasons in a year (Cline, 2012). While new trends are being launched almost every week, the goal of 'fast fashion' is for consumers to buy as many garments as quickly possible. It is therefore not unimaginable that 'fast-fashion' products are typically much lower priced and therefore making, beside competitive priorities, the cost-related drivers of manufacturing location decisions very relevant. The fashion retailer Zara for example also adopted gradually the change of operating on a business model of low quality and high volumes that required a different approach of manufacturing. It even "appears that instead of Zara changing the geography of jobs, the geography of competencies and jobs has changed Zara" (Tokatli, 2008). Industry 4.0 and the trend of fast products is especially being witnessed in the textile industry. Due to the fast-fashion business model, products are going from conceptual drawing to the shelf much quicker as ever seen before and at lower prices because production is moving closer to markets and shops (Wyman, 2015). This is especially an advantage for the companies since it also means that companies can avoid the risk associated with keeping large inventories of a design that they believe will be popular

(Wyman, 2015). Zara for example manufactures, distributes and sells clothing within two weeks after its original design appearing on catwalks (Wyman, 2015).

Also due to increasing risks of sustainability in low-cost countries, increased wages in Asia, quality issues, lack of flexibility, longer lead times and counterfeits textile companies are extensively considering to reshore (Hasan, 2018). Besides to stay competitive as homebased textile manufacturing company, the sector is heavily focused on manufacturing innovations (Hasan, 2018). Earlier manufacturing in the textile industry was centralized for better manageability and quality control, however thanks to Industry 4.0 is possible to control a lot more over the complete value and supply chains. Therefore it is a must for textile companies that want to compete in the latest industrial revolution to adapt or to copy the speed of business model of the fast-fashion. This means that the distribution channels will need to be redesigned and factories will need to be located closer to markets (Smithers and Gray, 2017).

The eight cases from the textile industry will provide this research with sufficient samples to make a good and thorough statement.

3.3. Data collection

The results of the case studies are compared with each other to identify the current and future status of Industry 4.0 and its influence on reshoring activities. Therefore, a multiple-case study will be done. A single case study is particularly useful to challenge or to confirm a theory while multiple cases allow a replication logic (Tellis, 1997). Especially since reshoring is a contemporary phenomenon, therefore a multiple-case study is useful (Yin, 1994).

Various production companies will be visited and qualitative data will be collected. There are multiple ways of gathering information through interviews. These interviews can be unstructured, semi-structured or structured. Since this research is embedded in a qualitative multiple-case study, the semi-structured interview is best suitable (Algozinne and Hancock, 2006). Through semi-structured interviews the respondents are able to provide this research the ability to yield an in-depth insight and the respondents are able to express themselves more freely. The main feature of the semi-structured interview is to facilitate the interviewees to share their perspectives, stories and experience regarding the phenomena Industry 4.0 and reshoring being observed by the interviewer. The targeted participants, in this case mostly CEO's, are the practitioners in their field, they will pass on their knowledge to scientific research through the conversations held during the

interview process (Boeije 2010). This method of interviewing is most often selected as the main method for collecting empirical data of the relevant practices. The interview stages encompass all stages from designing the questions for the interview, subsequently developing the interview guides until the process of the interview itself.

A semi-structured interview is also known as a non-standardized or qualitative interview method (Saunders, Lewis and Thornhill, 2009). These kind of interviews are a compromise of two types of interviewing, those are structured interviews and in depth interviews combined. For that reason, it provides the advantage of using a list of predetermined themes and questions as in a structured interview. However, a semi-structured interview keeps enough flexibility to enable the respondent that is being interviewed to talk more about any kind of topics that could be raised during the process of the interview. An in-depth qualitative interview is a more appropriate format for case study research due to the fact that in-depth questions cannot be answered very briefly. The anticipation therefore is that the interviewer will need to ask for examples or some more explanation on the answer given in order to gain a deep understanding of the issues. This approach will ensure that the research design and method of questioning is flexible and adaptive in order to facilitate new information to emerge or to adapt to an unexpected direction (Rubin and Rubin, 2011).

Industry 4.0 and reshoring are relatively new concepts and a company might not initially want to share all the necessary information because it is part of their strategy to remain competitive on the market. The informed consent will provide clear agreements with the interviewee of the company so that it prevents prejudices and withholding information. In addition, Industry 4.0 is a relatively new topic and it is not clearly defined in concepts and its future statuses are unclear. That is why a pre-test will be done to find out whether the definition concerning Industry 4.0 and reshoring and the questions are clear enough. Overall the goal is that this research approach can examine Industry 4.0 and its influences on relocation decisions of a company.

The table below depicts an overview of the conducted interviews. The column with the country represents the countries were the companies have offshored their activities to. Further companies' details are elaborated in chapter 3.4.

Table 1 – List with conducted interviews

Company	Country	Position	Type	Time	Date
Company 1	Asia	Business Development Manager	Telephone	32 min.	14-02-2018
Company 2	India, Vietnam	CEO	Face-to-face	37 min.	22-02-2019
Company 3	Romania	CEO	Face-to-face	46 min.	25-02-2019
Company 4	China	CEO	Face-to-face	44 min.	26-02-2019
Company 5	Mexico	CFO	Face-to-face	55 min.	27-02-2019
Company 6	China	Sales Director	Face-to-face	59 min.	08-03-2019
Company 7	Mexico	Commercial Manager	Face-to-face	36 min.	19-03-2019
Company 8	China	CEO	Face-to-face	47 min.	20-03-2019

The semi-structured interviews are divided into categories with several questions. These categories will contribute to get a fuller understanding of the Industry 4.0 process and its aspects regarding reshoring. These categories will help to analyze the collected data better. The categories or blocks will be further elaborated in chapter 3.2.2.

The interview will start with general information questions to get a general idea of the companies' characteristics and current state of affairs. Further the goal is to know what the current knowledge and state is of the Industry 4.0 at the interviewed company. The primary information will also provide an insight on whether the company is currently offshoring or has reshored already. Here it is also the goal to see if Industry 4.0 also had an impact on the companies' decision and if the implementation of Industry 4.0 brought any improvement or complications. At the end of the interview the respondents are asked to provide their own opinions concerning Industry 4.0 and reshoring and whether they would have acted differently in the implementation process considering their gained knowledge after the process.

The information of the interviews will be transcribed after the recordings. The transcription is necessary for re-examination and to get a better understanding for the answers of the respondents (Bell, Bryman and Harley, 2018). Furthermore, the interviewer and the respondents will also be able to focus more on the interview and the discussion, since the transcription will take place afterwards. The following step is to go multiple times through the gathered data before the analysis.

This step is of great importance to have a good processing of the collected data (Patel and Davidson, 2011).

3.3.1 Preparation of the semi-structured interviews

First a desk-research will be conducted for the following reasons; to learn about the subject and to know more about the company. Background information about the company acquired will be applied in order to be able to have a better understanding of the company and that can be used in the interview.

A pilot study is constructed concerning the understanding of Industry 4.0, reshoring and the questions of the semi-structured interview. This pilot study aims at what the best way is to test the understanding and the knowledge of the respondents about Industry 4.0 and reshoring. This is especially needed in order to do an accurate and dependable research on Industry 4.0 and its possible influence on reshoring. The semi-structured interview with its qualitative aspects will refer to current states and desired future states of Industry 4.0 even as what companies' representatives will think of Industry 4.0.

The goal is to interview several Chief Executive Officers (CEO) of textile companies that have reshored, or other firms, organizations that are affected by reshoring. The interviewees that will be interviewed are asked open questions about their general views, experiences, and concerns on Industry 4.0 and reshoring, as well as, what they base this knowledge on. Data is also gathered by researching the websites of the interviewed firms. As mentioned in the informed consent all of the gathered data will be anonymized to ensure full confidentiality and to prevent the spread of competition sensitive data.

3.3.2 The semi-structured interview

After obtaining the informed consent the interview will start. Background information about this research is included on the information sheet of the informed consent. Before starting the interview, the purpose of this research will be explained. Subsequently the interview guide will be followed. By using a well prepared interview guide a high level of unnecessary information will be reduced and the data within the areas of interest will emerge (Morse & Field, 1996).

The questions are grouped into five thematized blocks of questions. These blocks are ordered by a logical sequence to facilitate the respondent as much as possible (Boeije, 2010). For

reliability reasons and to guarantee a similar understanding about the research subjects, a clear definition of Industry 4.0 and reshoring will be provided first. Then, each block will be introduced with a lead question.

The first themed box provides general background information about the respondent and its position within the firm. The second box investigates the respondents' view on Industry 4.0 and reshoring. Subsequently the definitions from this research will be provided to ensure that there is a consensus between the interviewer and the respondent about the definitions used in further questions. The goal of the third box is to obtain an overview and a starting point for further questions about reshoring and Industry 4.0 of the company involved. This is of great importance since the company should have had or has a project at the intersection of both industry 4.0 and reshoring. This is important in order to find a clear answer on the research question. Overall this box will provide a so called 'reshoring vignette' that contains overall information.

The fourth and fifth box are somewhat intertwined. If some of the drivers of the conceptual model are mentioned by the respondent here, they will be excluded at the next block.
However there is a clear distinction between the goals of these two boxes. The main purpose of the fourth box is to identify strengths or problems of the reshoring project. To have a better understanding of the motives to reshore it is also important to understand what the initial motives were to offshore. The first question is a relative open question and will allow the respondent to speak freely concerning the issues involved of Industry 4.0 and their reshoring project. The choice for this open question has been done deliberately to prevent putting any terms of interest in the mouth of the respondent. This has been done to enhance the objectiveness of the interviewer and therefore the interview.

The fifth box is there to find out what the current and required state of the Industry 4.0 and reshoring project is. The conceptual model encompasses a great number of drivers of which the influence of Industry 4.0 needs to be researched. Therefore any drivers that have not been mentioned before will be addressed here. Answers shall then be used in order to analyze the possible influence of Industry 4.0 on the drivers. The last box will try to get a grasp of the analysis of the company itself about reshoring and or Industry 4.0. The goal here is to see whether there are similar trends or difficulties to be observed from a practitioners point of view. At the end all of the transcribed answers are possible to compare.

3.3.3 Data Analysis

From the collected interviews the data shall be stored, categorized, named and connected. This process actively involved interpretations from the researcher (Boeije, 2010). Through coding techniques it is possible to organize the data and to reduce it in relevant themes to represent the data (Creswell, 2017).

Coding can be differentiated into three kinds of coding which all contribute differently to the analysis process. Descriptive coding just stores information; to develop concepts mostly analytic coding is used and topic coding identifies material through themes (Morse and Richards, 2002). Topic coding is therefore the best approach since it is especially compatible with both the systematic structural coding applied to the transcripts (Guest, MacQueen & Namey 2012) and a grounded theory approach. This approach utilizes an iterative, inductive, and deductive process, and places great emphasis on simple systematic procedures to allow emergence of a new theory (Corbin & Strauss, 1998). Especially since coding is referred to as the process of 'breaking down, examining, comparing, conceptualizing and categorizing data' (Corbin & Strauss, 2007, p.61). After all of the data has been gathered, it is transcribed and subsequently carefully divided into fragments. These fragments are grouped into the same category and labeled. This makes it easier to compare them among each other. "Qualitative codes take segments of data apart, name them in concise terms and propose an analytic handle to develop abstract ideas for interpreting each segment of data" (Charmaz, 2006, p.46). The goal is to research the possible influence of Industry 4.0 on several categories for reshoring decisions subdivided by its drivers making coding the best way to operate. Especially because this coding technique contributes to a clear organization of the data and resulting in a indexing system that fits the analytical needs of this research (Boeije, 2010). At the end the research questions are the tool for determining the relevant data that has been covered with the generated codes. This entire coding process has repeated itself several times.

3.4 Describing the case companies

A short description of the interviewed companies shall be provided. Followed by the overall findings from the performed interviews.

3.4.1 Company 1

First to be interviewed was a business development manager at the textile branch organization of the Netherlands. This organization provides innovation sessions where they share their vision on developments in the textile industry. During these sessions they discuss many topics, among reshoring and Industry 4.0. Except for these sessions, the business development manager also assists companies in implementing Industry 4.0, that sometimes are followed by reshoring activities. The branch organization supports also a business network of manufacturers, importers, agents and wholesalers in clothing, fashion accessories, carpet and (interior) textiles that could provide a lot of information. Within this network there is a lot of knowledge about textile companies and their latest trends. Especially what the current challenges are and how they view this from a perspective of Industry 4.0. While this is not a sole SME, the manager however has been involved in a lot of Industry 4.0 and reshoring projects at SME's. Therefore, the first interview was able to provide a unique overall insight that was valuable for this research.

4.1.2 Company 2

The second company is a producer for woven labels and textile stickers. The company has productions locations India, Hong Kong, Vietnam and The Netherlands. Now they are currently considering investing in more intelligent machines closer to their home base in the Netherlands for the production of RFID chips. These microchips are able to be embedded in clothing to combat counterfeit products, improve in-store shopping, control inventory and to track samples. They also want to invest in Belgium in order to start a seamless chain from a to be set up webshop to the customer.

4.1.3 Company 3

This company was founded in the beginning of the 20th century. The company started with the production of hair cloth, horsehair and tie linings with wool, cotton, polyester, viscose etcetera. A large part of the products they manufacture go abroad where the company is known for their quality and reliable delivery times. In addition, they have the option to quickly produce any desired quality to meet the specific wishes of the customer. It was vital for the company to move more and more towards tailor made solutions for their customers. Nonetheless to do this for a big market Industry 4.0 is of great importance. The company had to consider the implementation of a digital roadmap for their processes. Through the maximal use of data the company hopes to take its production company to the next level. This development transforms a old-fashioned factory to a more Smart Factory. This means that all relevant data are aggregated and analyzed and that based on that data the necessary correct actions are taken. In the Smart Factory, sensors, machines, employees and processes are part of a connected ecosystem that improves the production process in the following areas: Less downtime, less surplus and dropout and better insights. The whole process can be monitored from start to finish.

4.1.4 Company 4

The fourth company produces trendy textiles and home decoration. It has more than 200 years of experience in the textile industry. Ever since it was founded by one of the biggest textile families. Their products can be decorative fabrics to bathroom textiles. Currently the design takes place in the Netherlands and the production is outsourced in China. The company is right at the brink of making an investment decision to produce closer to their home market in Macedonia. High tech machines and smart infrastructure will allow the company to produce and to deliver faster. However, the company still faces some implementation challenges.

4.1.5 Company 5

The fifth company is also located in the Netherlands. They have several locations in Mexico, U.S.A. and a large facility in the Netherlands. The company heavily invested in high-tech warping machines in order to gain a lead and to have better highly innovated fabrics. As a ground breaking company it is constantly trying to innovate and improve its products. Currently they are involved in expanding their activities in Mexico. Mexico will have to serve the local and North-American market. They will realize this by means of research and development and through combining the unique features of circular knittings, elasticity, yarns and finishing. Currently the company offers flexibility as well as the highest quality. This is possible because of the mutual exchange of knowledge, techniques, processes as well as creativity. Therefore it is well-known for its innovated fabrics.

4.1.6 Company 6

The sixth company has a sales office in the Netherlands, however its main manufacturing location is located in Germany. This company focusses on industrial textile hook and loop fastening systems. With their large range of products as a hook and loop tape manufacturer the company is able to offer suitable solutions for almost every requirement. Their main focus is to become an industrial partner for their customer and to achieve high quality, individual service and rapid delivery times. However, delivery times are under pressure since some processes are outsourced in China. By making innovations in the production process through Industry 4.0 in Germany it could shorten its delivery times. The company wants also to set up a webshop that is directly connected to their warehouse and production facility. This makes them able to serve their customers as quickly as possible without losing their aim of high quality.

4.1.7 Company 7

The seventh company has had some of their products outsourced in China. Subsequently they wanted to produce in-house closer to their home market (Europe). Nowadays it is active in the automotive industry for technical textiles. The company is not the oldest textile factories, but it is one of the few companies that has survived. Especially due to the turbulence of the market in the textile industry. One of their key strategies was to immediately invest every earned penny in new machines and techniques. A healthy policy which has, in combination with a choice for diversification that led to successful growth. The company wants to move to a production location closer to their sales office in the United States. The new facility will be in Mexico to serve the local and North-American market. The company there will be provided with state-of-the-art techniques for production areas and logistics. These techniques will provide a major insight since Industry 4.0 has enables a company to remain very competitive.

4.1.8 Company 8

The last company was situated in the Netherlands. The company is a manufacturer of cocktail table covers, fitted table covers, tablecloths and table skirts, chair covers and accessories etc. The company also initially outsourced its production in China until it decided to move closer to their home market. In 2014 the company started a manufacturing facility in Macedonia, where in 2017 they moved again. Thanks to Industry 4.0 (more machines, digitalisation etc.) exports from the plant to the warehouse occur twice a week and only takes approximately two business days.

4. Results

4.1 Pretest

As mentioned earlier a pretest has been executed in order to test the internal validity of the questions of the semi-structured interview. The initial goal was to do the pretest in a real-time environment, thus a company with experience on reshoring and Industry 4.0. The general manager of a consulting company was willing to cooperate with the pretest. The consulting company provides project management and consultancy services for Dutch companies with international activities. These activities can be offshoring, reshoring and any further kind of financial services. The pretest has been recorded, however further analysis through coding techniques has not been applied, since the goal was to test the drafted questions and not to develop a theory based on the acquired answers. Overall the pretest has shown multiple insights that provided a solid base to change one and other.

The intention was that the semi-structured interview would take up to 45 minutes, however in practice the interview took over one hour and 40 minutes. Therefore, it was a must to minimalize the length and number of questions and to look at which questions are necessary and which one are not to test the conceptual model. Consequently, some broader questions and questions that considered earlier offshoring experiences have been removed. This has been deliberately done since earlier motives of offshoring are not relevant for the conceptual model. Especially since the conceptual model tests whether Industry 4.0 has any influence on reshoring activities instead of offshoring activities. Before executing the pretest, the 27 chosen drivers that could be influenced by Industry 4.0 were included in the list with questions. However, the question with all of the drivers prolonged the interview and caused ambiguity, unfamiliarity with the terms at the interviewee. For these reasons only the questions with the possible influence of Industry 4.0 on each of the four categories of reshoring decisions are included. If needed the categories were further explained by the interviewer. Through this way the chance of the interviewer putting any words in the mouth of the interviewees are decreased. Besides the interviewee could provide any other kind of drivers that they deem as relevant and are being influenced by Industry 4.0.

4.2 Transcripts

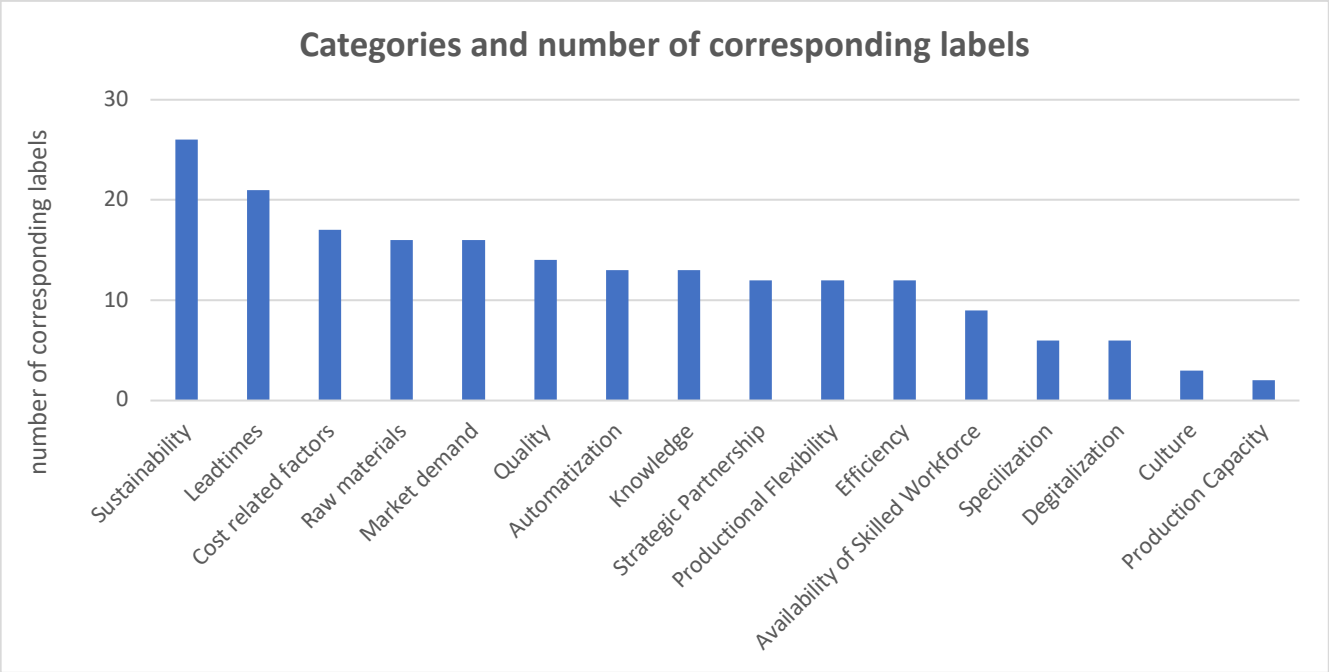
The interviews were in Dutch and therefore all of the transcripts are in Dutch as well. No translations have been made in order to prevent the loss of key information. The translation could impact the overall quality and have a significant implication on the conceptual equivalence and accuracy of the study findings (Temple & Young, 2004). For example, the translator will not only translate the texts literally, but also adds cultural or interpretive insights.

Overall there are 47 pages in total of the transcripts and the interviews took 44,5 minutes in average. First the transcripts were browsed through as a whole and notes about first impressions have been made. Then the transcripts of the interviews were read carefully one by one and line by line. All relevant words, sentences or sections relating to Industry 4.0 and reshoring have been labeled. These labels were about opinions, differences, actions or anything else that was relevant to this research. The relevancy was determined by the fact that it was repeated several times, the interviewee stated that it was important, or it had a close connection to the topic of this research. After coding the transcripts, the most important codes were brought together by grouping them into conceptualized categories. Not all of the codes that were created have been used for these categories as these labels turned out to be not relevant. By following the previously mentioned actions the data is being conceptualized. In the next chapter the categories are being described and how they are connected with Industry 4.0.

4.3. Labeled categories

Through topic coding 330 fragments were identified. All of the codes had a direct connection to Industry 4.0 or to the conceptual model provided in Figure 6. 279 labels have been grouped together and divided into 16 categories. These categories were arranged according to the number of codes for each of the category;

Figure 6 - Categories and number of corresponding labels



1. Sustainability (26 codes)
2. Lead times (21 codes)
3. Cost related factors (17 codes)
4. Raw materials (16 codes)
5. Market demand (16 codes)
6. Quality (14 codes)
7. Automatization (13 codes)
8. Knowledge (13 codes)
9. Strategic partnership (12 codes)
10. Productional flexibility (12 codes) Flexibility of production and low production volumes
11. Efficiency (12 codes) Less faults in production
12. Available skilled workforce (9 codes)
13. Specialization (6 codes) More complicated products
14. Digitalization (6 codes)
15. Culture (3 codes)
16. Production capacity (2 codes)

Sometimes a code was only mentioned one time, however for this research is has been deemed as relevant to the investigated topics. These codes are not included in the overview above but are being mentioned in the following paragraphs in quotes. The interrelationships within and between the themes Industry 4.0 and reshoring drivers are presented below.

4.3.1 Industry 4.0 and Risk, uncertainty and ease of doing business

As shown in Figure 2, where the conceptual framework for this research is shown, there are multiple categories of drivers of the reshoring process that could be influenced by Industry 4.0. In this and the following subchapters (chapter 4.3.1 – 4.3.4), the findings will be discussed how Industry 4.0 influences each of the reshoring drivers separately. In other words, which categories and corresponding drivers are influenced by Industry 4.0; and therefore, will be taken into the new framework or have been left out.

The first category is *Risk, uncertainty and ease of doing business*. The drivers behind this category (labeled 1.1 – 1.6 in Figure 5) are embedded within the goal to reduce the exposure to risk, uncertainty through reshoring and subsequently to have the same or a more efficient operation in the domestic location of the firm (Benstead, Stevenson and Hendry, 2017).

Driver 1.1, 1.2, 1.3, 1.5 and 1.6 are being influenced by Industry 4.0 for the following reasons:

- Driver 1.1: A connection between Industry 4.0 and the drive to reduce the risk of supply chain disruption has been found. Supply chain has been coded four times and has been categorized into the category *Lead times*. This has been done because Industry 4.0 would increase efficiency and shorten the overall lead times for companies. However also disruption of the entire supply chain is also reduced. As company 4 stated *"You have to imagine that a company like ours, that we have to make decisions at a very early stage about numbers, about colors without having already sold anything. That means risk. It must be because you have Lead times of 3 to 4 months in China. If you could reduce that to 1 month, you can limit the risks"*. And company 6 stated; *"we can digitize the warehouse, the fewer errors the better… being able to send things as quickly as possible and exclude incorrect shipments"*. Shows that risk is being reduced by the possibilities Industry 4.0 brings to supply chain disruption risk.

- Driver 1.2: Another driver that is being influenced by Industry 4.0 is cultural distance improvement **(**Tate, 2014 and Gray et al. 2013). As company 4 stated; "*you have to deal with character traits, with culture so all issues we have to deal with… the entire culture of Africa (that part) is a mentality hard to work with. There is no drive there, there is no ambition… There is also a lot of corruption from the government*". Company 8 complements this with; "*I look at corruption, I look at what the people are like; culture*". All the above indicates that cultural distances make it challenging to develop the needed levels for the implementation of Industry 4.0.
- Driver 1.3: Offshore legislation minimalization, while this is a driver to reshore it however works in this case the other way around. Company 8 states that the implementation of Industry 4.0 is being hindered because "*a lot of rules are imposed; How is it possible with import duties, anti-dumping, yarn purchases, the currency, etc*.?". Thus the increase of offshore legislation and the minimalization onshore increases the need to implement Industry 4.0 with reshoring or nearshoring. Driven by legislation that is been enforced by the European Parliament to develop an Action Plan for Industry 4.0 (Smit el al., 2016). Creating therefore the EU a more friendly environment for certain companies to reshore and to invest in solutions relevant to Industry 4.0.
- Driver 1.5 and 1.6: Environmental issues reduction and social issues reduction, as seen in Figure 6 sustainability is a topic that has been coded many times. Driver 1.5 and Driver 1.6 show that Industry 4.0 expands the opportunities of sustainable manufacturing. The empirical findings show that these opportunities provide better working conditions. As company 2 said that; "*specifically for clothing, I also think it (Industry 4.0) fits with working conditions".* Complemented by company 1 stating; "*it (Industry 4.0) does contribute to making production facilities more sustainable… It is growing, and so is the awareness that we should no longer have any misery in countries like Bangladesh. That you as a company are also partly responsible for that."* Except for the working conditions, also environmental issues are mentioned as by company 6 stating; "*We get requests from a large chair builder, who says yes: I want everything into one, a 3D product that is also good for the environment because then you will no longer have emissions (with the production)".*

Driver 1.4 is the only factor that has no connection to Industry 4.0:

- Driver 1.4: Global economic conditions, from literature review it was assumed that there was a possible influence of Industry 4.0 on reasons why firms would reshore. However, no empirical evidence was found that this driver is likely to be influenced by Industry 4.0. Only one relevant sentence was coded, whereby company 5 stated that "*the American market has increasingly opened in the last ten years, it used to be really nationalistic, it still is today. But that may be because it has Trump. However American companies are increasingly open to foreign production units".* Indicating a global economic condition of the openness for products from outside the U.S. market, but this is not a clear global economic condition that is being influenced by Industry 4.0. It rather indicates the willingness of importing goods of a certain country on a national level.

4.3.2 Industry 4.0 and Cost-related drivers

The second category (see Figure 5) is called *Cost-related drivers*. The conceptual framework consisted of nine drivers, labeled 2.1 – 2.9, however only 2.1., 2.2., 2.4, 2.7 and 2.9 have been found to be linked to Industry 4.0 and reshoring. Industry 4.0 influences cost-related drivers of reshoring in the following ways:

- Driver 2.1: Labour cost reduction, within the textile industry there is confection which is mainly hand technology (McKay, 1978). Industry 4.0 could reduce the amount of manual labour needed as company 2 stated; "*what we are working on is weaving products in one go…90 confection minutes…to 10 confection minutes".* Followed by company 4 stating; "*Although someone there (Bulgaria) costs 250 euros in a month, apparently it is very important to cut those costs away."* Together stating with company 3 that; "*it is the return of production. From low-wage countries to Western Europe.*" Despite the fact that *"then you have to deal with wage costs that are all much higher in the Netherlands"* (company 3). Showing that labour-cost is being influenced by Industry 4.0.
- Driver 2.2: Labour productivity improvements, Industry 4.0 can improve the labour productivity by a more efficient production. However, for these improvements the right laborers are needed as company stated; "*still looking for the good people who indeed manage to achieve high efficiency".* And company 4 said: "*a smart set up is needed to*

ensure efficiency. Then you can reduce the chance of overall errors… Then efficiency and smart technology are of course much more important."

- Driver 2.4: Transportation cost reduction is being influenced by Industry 4.0 since "*you have to work with data and you will have to organize your production processes and logistics differently. And you will have to do it closer to home, because otherwise you won't be able to do that"* (company 1). Indicating that through the use of data transportation cost can be reduced. Followed by company 4 saying that; "*efficiency goes much further than just perfecting work, wrapping, packaging and the logistics part*". And company 7 summarizes this by stating that; "*It (Industry 4.0) saves logistics, it saves costs…there is a large distance, so the logistics costs are quite high*."
- Driver 2.7: Coordination and monitoring cost reduction is a driver for reshoring that also is being influenced by Industry 4.0. Company 2 has introduced Industry 4.0 and therefore reshored its activities from China to the Netherlands. Company 2 has now lower monitoring and coordination costs in comparison to producing in China. They stated that; "*It is also about organizing. I mean if you do this in China you have to be able organize it… for us it is also much less hassle. Because… if there is a problem, you just drive to Waalre (the Netherlands) for a day…And then it's solved".* Also confirmed by company 8 saying that "*It had to be arranged that I was the manager and that happened in one day…in the Netherlands everything is digital*". Indicating that a short distance to a reshored production location with implementations of Industry 4.0 enables companies to reduce the time and thus the costs of monitoring and coordination.
- Driver 2.9: The capacity utilization improvement onshore is the last driver of this category being influenced by Industry 4.0. Company 2 stated that trough smart industry "*a higher production capacity can be achieved*". And that trough Industry 4.0 a higher efficiency in the production line can be achieved. Resulting in being able to utilize the overall production capacity. However therefore larger production output is required since company 4 stated; "*The moment you say the production numbers are huge and the margins are paper thin. Then efficiency and smart technology are much more important*". Company 8 stated also that their production increased since "*I believe that the efficiency (Macedonia) is higher than in China. Production is also more difficult in China."* Showing that the capacity in a nearshored country is being better utilized than before at the offshored production location.

Drivers 2.3, 2.5, 2.6 and 2.8 have been removed from the conceptual framework as they have no connection to Industry 4.0. Duty cost reduction and Energy price reduction were not mentioned by the interviewees. Production cost (non-labour) reduction and Working capital/pipeline reduction were mentioned, however an increase of costs was mentioned. Company 5 asking themselves *"how are we going to finance that?"*. Indicating that the implementation of Industry 4.0 comes with high costs and the need to be financed. Company 1 stated; "*But what a SME can do (for Industry 4.0) is limited. Because of financial resources and the influence they have on a total sector or industry*". And company 2 stating after the investments of Industry 4.0 were done "*We actually finance all these developments from our own resources…And now we are on the point that we say: now it has to result in something (earnings)".* Therefore above mentioned drivers will be eliminated from the framework, while these have an effect on reshoring decisions, Industry 4.0 is not reducing the costs, rather it is increasing (initial) costs.

4.3.3 Industry 4.0 and infrastructure related drivers

The third category, shown in Figure 5, is named *Infrastructure related drivers*. The corresponding drivers are numbered 3.2 and 3.3. The empirical findings showed however that driver 3.1 is not being influenced by Industry 4.0.

Driver 3.2 and 3.3 are linked to reshoring and Industry 4.0 influences these links for the following reasons:

- Driver 3.2: Skilled human resource availability was of great importance for the successful implementation of Industry 4.0. Company 1 stated that; "*The machines are still manageable, but the biggest problem was the availability of staff*". Indicating that the investments of Industry 4.0 abroad would be difficult, because no skilled staff would be available. Company 4 had to deal with the same challenge since they stated: "*Getting skilled personnel is just very difficult in China*." Company 7 said that there was a larger availability of skilled personnel in the Netherlands. This is mainly because of the long history and experience people have in certain sectors. Especially in the textile sector company 7 stated that; "*because there is more experience and you have regions where there was a textile sector in the past and there are people that are just better trained*."

Concluding that the availability of a skilled workforce is beneficial for the implementation of Industry 4.0.

- Driver 3.3: Industry 4.0 is directly linked to automated machinery. Companies were mostly driven by innovations that Industry 4.0 brings to the production process. Company 1 mentioned a fully digital production process in which hand labour is also been reduced or even automatized. The company mentioned that there is even a fully dedicated website for innovations in the automatization within the textile industry. However, company 2 expressed that; "*it is still a long way of development*". And company 8 is continuously developing automation through Industry 4.0. They said for example; "*so that is a model for which we will develop a robot. Until the warehouse everything automatized… nowadays you have fully automated warehouses with robots. Everything is digitalized and automatic, that is my intention."* Indicating that automated machinery is apparently a continuous goal for business processes in the manufacturing industry.

Driver 3.1 is not linked to Industry 4.0 for the following reason:

- Driver 3.1: Raw material supply network issues offshore is a driver that was mentioned multiple times, however it is not being influenced by Industry 4.0. While companies have been reshoring, Industry 4.0 did not seem to affect the supply network of raw materials. For example company 1 stated; *"You may want to start producing the Netherlands, but where do you get the raw materials from?"*. Company 2 added that with production in the Netherlands the raw materials still have to be sourced from abroad by stating; "*If you want something here then you have to get your fibers from there (China)*". With the implementation of Industry 4.0 the raw material supply network remained an issue as mentioned by company 4 saying that; "*Our problem is that we have to manage the logistics of the fabric. Almost all of the fabrics that we now use come from China*". Making it clear that the supply of raw materials for the production in a reshored country is still very important, yet not being influenced by Industry 4.0.

4.3.4 Industry 4.0 and Competitive Priorities

The last category shown in Figure 5 is named *Competitive Priorities*. In the conceptual model nine drivers were part of this category, labeled as driver 4.1 – 4.9. However only driver 4.1, 4.4, 4.5, 4.6, 4.8 and 4.9 are directly linked to Industry 4.0 for the following reasons:

- Driver 4.1: Industry 4.0 improves the flexibility of the production of companies. One reason was the fact that for the implementation of Industry 4.0 in offshored countries was less flexible in comparison to reshored countries. Company 4 namely stated that; "*you see that China is becoming very quickly more expensive, but also much less flexible*." Industry 4.0 improves the flexibility of production processes and for company 4 that was also of great importance. As can be seen by their statement; "*Our production has a lot of changing colors, a lot of changing articles, flexibility… is therefore important*.". And company 6 said; "*it is possible to place the robots somewhere in Germany… Then you have enormous flexibility*." Company 2 explained the increased need for flexibility by saying; "*Less predictable consumer demand is increasing*." Innovation through Industry 4.0 has made it possible for companies to serve a larger variety of products in smaller volumes. Therefore their overall flexibility has increased.
- Driver 4.4: Companies mentioned that Industry 4.0 contributed to the speed to market improvements for new products. Company 1 underlined this aspect by mentioning the issues of fast-fashion, stating; "*Fast-fashion is trying to meet the wishes of the consumer as quickly as possible…Only nine weeks. Yes, you will still have to work with data and you will have to organize your production processes and logistics differently. And you will have to do it closer to home, because otherwise you won't be able to do that*." The business model of company 2 mainly depends on this driver as it becomes evident from their following statement; "*A new way of producing such as 3D printing of a product. Also directly from online into the factories. Directly developing the new product*."
- Driver 4.5: Industry 4.0 enabled companies the improvement and adoption of innovations and new production processes. Company 1 mentioned this by stating; "*Product innovation, through producing products smarter. Then it also becomes more interesting to do it in the Netherlands."* For company 2 the possibilities of innovation was even existential for the company's existence. This became clear by their statement; "*We must innovate in order to*

keep earning money." However, perhaps not directly linked, but innovation through Industry 4.0 enabled companies to produce more cost-effective in comparison to offshored countries. Company 6 mentioned; "*They (production partner) have optimized the entire process (through reshoring) and they are now cheaper than they were in China*".

- Driver 4.6: As mentioned in the literature review hardly any research was available for knowledge retention (driver 4.6) and intellectual property protection (driver 4.7) linked to Industry 4.0. However, companies mentioned that they rather invest for Industry 4.0 in their homebased country. The reason for this was that, when implementing Industry 4.0 abroad, the export of knowledge would create more competitors. Company 6 said that they; "*are careful of not informing the staff too much and that the know-how remains in the Netherlands*." The same company mentioned an example in which a Dutch company has had to sell its activities abroad and therefore unwillingly has created its own competitor. As can be read by their following statement; "*The know-how, it simply shifts whether a company (when it has offshored activities) wants to or not. And then a foreign company may think we can do it ourselves too and then you have created a competitor, and that happens a lot. But yes, as it is with smart industry, if you do things yourself you can keep everything in your own hands.*"
- Driver 4.8: Industry 4.0 has been found to improve product quality, making it therefore also a factor that influences this category. Quality has been coded 14 times and shows the significance of this driver for Industry 4.0. Company 6 stated that Industry 4.0 especially enhances the quality in a reshored country in comparison to an offshored country. They stated; "*You can still distinguish yourself whether you have good or bad quality. Because there is a lot of junk from China in terms of quality*". Followed by company 7 that stated that it is important "*to prove that you deliver good quality product*". Companies gave multiple examples for how Industry 4.0 could do that. Company 1 gave the following example; "*Data goes back into the entire chain. That can be for fabric quality*".
- Driver 4.8: Industry 4.0 also facilitates the added value of 'made in' brands. As mentioned earlier sustainability is impacted by Industry 4.0, however it also related to this driver. Company 1 namely mentioned that made-in-effect is also important for sustainability. By digitalizing the entire process companies can prove or enhance sustainability. They stated; "*Made in Europe, well that is produced responsibly. And therefore we even see Chinese*

factories in Italy." Company 2 also uses Industry 4.0 to be able to make their products in the Netherlands. Through a digital design and their high-tech weaving machines their products can be produced in the Netherlands. *"(The made-in-effect) for the consumer and that's how we present it. It is all the Netherlands*". Company 6 however made a nuance to all of the above, since they said; "*I don't think it's easier to sell it as made-in-Germany,…however you see everywhere that they prefer to have a German company as their contact".* Despite company 6 being the only company somewhat opposing the influence of Industry 4.0 on the made-in-effect, three other companies acknowledged the beneficial influence of Industry 4.0. Therefore this driver has been chosen to be included within the framework.

A direct link between Industry 4.0 and the drivers 4.2, 4.3 and 4.7 has not been found. Dependability was mentioned a couple of times but not in the context of Industry 4.0. Dependability was only referred to in terms of a dependable partner and dependable transport. Therefore driver 4.2 is not included in the model. Responsiveness and intellectual property protection were not mentioned nor in different contexts, therefore drivers 4.3 and 4.7 are also removed from the model.

5. Discussion

5.1 Limitations

This research is based on existing literature about reshoring. Research questions are drawn based upon the existing literature and were subsequently researched. This was done in cooperation with Dutch, German and Mexican companies in the textile industry that are planning to reshore or already have reshored their in-house, outsource or offshore manufacturing. For that reason these findings will not necessarily be applicable to other originating countries than the Netherlands, Germany or Mexico. Additionally, existing knowledge of reshoring is mostly enabled by competitive manufacturing strategies in high-cost locations, therefore it is limited particularly in context to labor-intensive industries, like textile and clothing (Pal et al., 2017). For this reason the focus for this study is primarily on the textile industry and thus the findings could provide a distorted view on other industries that have different traits and characteristics.

5.2 Disposition

It can be expected that the impact of Industry 4.0 outweighs the initial drivers for offshoring, so that firms are now reshoring. In order to get a grasp of the influence of new technological developments on reshoring, it was important to do additional research. The framework of Benstead, Stevenson and Hendry (2017) describes the influence of reshoring drivers on implementation considerations. This study is a follow-up study that researched the influence of Industry 4.0 on the drivers proposed in the framework. The need for this research was also evident from the research of Barbieri et al. (2018). For that reason it was of great importance to control for contingency factors in order to refine the reshoring framework itself (Benstead, Stevenson and Hendry, 2017) within the textile industry. Not all the interviewed companies had already finished their Industry 4.0 and reshoring project. Sometimes the companies were still in the middle or were making preparations before the actual project was taking place. The researchers of the original framework constructed their finding based only with an ex-post analysis about reshoring. To get a full understanding it was important to go further and thus not only to investigate why, but also what drove a firm to reshore, what the influences of Industry 4.0 were and what relevant drivers are before (ex-ante) the transition for companies within the same industry.

Since the phenomena of Industry 4.0 and reshoring are rather new, the theories are new and not all companies had the same understanding. However, this was controlled through the fact that the definitions of this research were shared with the interviewed companies. Followingly all of the data from the research was coded and analyzed trough qualitative research methods (Boeije, 2009). The retrieved data will be interpreted below for a final conclusion.

5.3 Answer on research questions

Following the results from chapter 4.4 the research questions of chapter 1.4 can be answered. The question was: Which reshoring decisions regarding (a) Risk, Uncertainty and Ease of Doing business, (b) Cost-related drivers, (c) Competitive priorities and (d) Infrastructure-related drivers are influenced by Industry 4.0 in the manufacturing industry?

The first step to answer the research question was to remove the drivers from the framework that were not categorized through the coding techniques (see Figure 7). That would result in the adjusted model shown in Figure 7. While not every driver is being influenced by Industry 4.0, from Figure 7 it becomes evident that all of the categories of the original framework of Benstead, Stevenson and Hendry (2017) are influenced by Industry 4.0. The figure shows that Industry 4.0 has an influence on (a) Risk, Uncertainty and Ease of Doing business, (b) Cost-related drivers, (c) Competitive priorities and (d) Infrastructure-related drivers for reshoring decisions.

On first sight one might assume that a category is more influenced than the other because there are more drivers (e.g. Competitive Priories vs. Infrastructure-related), but this is not the case. The weight factor of the categories should not be weighed by the number of drivers in each category, especially since some of the categories from itself have fewer drivers in comparison to other categories. Rather it is of great importance to focus on the weighted outcome by number of codes of each category (see figure 6).

Most striking then is that sustainability was one of the most mentioned topics in the interviews. This proves that that Industry 4.0 had especially an effect from a sustainable point of view in the textile industry. Companies said for example "*sustainability can be made digital and transparent by proving in the entire chain where the end-products originate from. This may be also fabric quality, but it can also be where production actually takes place. That can be about safety, that can be anything"* (company 1). And another company contributed to this by stating that *"(Industry 4.0) guarantees that you produce it under good conditions. For sustainability."*

(Company 3). While the previous quotes are a good ground for implementing Industry 4.0 for increasing the sustainability of a company, the influence of sustainability however needs further to be researched. From interviews it became clear that sometimes Industry 4.0 enables companies in becoming more sustainable, thus affecting drivers 1.5 and 1.6. However sometimes companies argued that through external pressure for becoming sustainable, companies have had to resort to Industry 4.0. As can be seen from the argumentation of company 1 stating; "*There is enormous pressure on countries, to become more cleaner, more sustainable and more responsible*." Making it likely that Industry 4.0 is also being influenced by sustainability. Therefore sustainability influences Industry 4.0 and subsequently reshoring. Thus Industry 4.0 seems to act as an enabler for sustainability in manufacturing companies. However more research is needed to understand the full context of sustainability. Especially since sustainability is a broad topic and could affect Industry 4.0 in multiple ways. For example company 1 has given the consideration that; "*There are plenty of companies that say it must be greener and more responsible. But what she can do is limited, because of financial resources...".* And the effect of larger companies have to be taken into account as well. Company 1 namely argued further that; "*If even H&M takes a small step, it will have far more consequences on a global scale than all those smaller companies put together. Small companies then will have to follow, otherwise they will be pushed out*". Showing that there is also an upcoming competitiveness in the field of sustainability that drives companies to implement Industry 4.0.

Drivers that are not influenced by Industry 4.0 are global economic conditions, duty cost reduction, energy price reduction, production cost (non-labour reductions), working capital/pipeline cost reduction, dependability, responsiveness, know-how retention and intellectual property protection. These drivers seemed less relevant and some of them are therefore not being affected by Industry 4.0. Since all of the categories for reshoring decisions are influenced by Industry 4.0 the conceptual model of Figure 2 is proven.

Lead times was also a major factor to be influenced by Industry 4.0, in fact with sustainability it was the only topic being mentioned above 20 times. The companies stated that this was the case due to pressure from the market. Company 1 stated that *"the result of all digitization is that it is possible to reduce lead times. To preserve the fast-fashion industry… you have to reorganize your production processes and logistics and therefore you will have to do it closer to home, because otherwise you won't be able to do that."* This proves that for companies in the

textile industry it is a must to implement Industry 4.0 in order to cope with the increasing demand of customers, especially in the fast-fashion industry. Company 2 underlined this by saying that there is a "*less predictable consumer demand, so you must have shorter delivery times".* Reducing lead times by producing closer to home and having Industry 4.0 will also reduce faults and making the processes more efficient. As company 6 stated that they are *"able to send everything as quickly as possible and exclude incorrect shipments"*. And some companies had multiple products that were able to be shipped quickly, but not all of the products. Therefore they felt the pressure and demand that *all* of their products had to be delivered in the same place. As company 2 pointed out that *"you have a super service in 7 working days to deliver. And then other products last 3 weeks. That is simply not a consistent message"*. Industry 4.0 and reshoring enables therefore a more efficient production with shorter delivery times.

As shown above Industry 4.0 tends to influence drivers in multiple factettes and at the same time it is also being affected by sustainability. While the influence of Industry 4.0 on all of the categories has been proven, there are also other factors that influence Industry 4.0 itself. As company 1 said; "*in this way, those themes lie over each other like Venn diagrams and where they overlap, there we really see the innovation".* Underlining that this research has only raised the corner of the veil of Industry 4.0 and its effects on the manufacturing industry.

5.4 Managerial implications of the findings

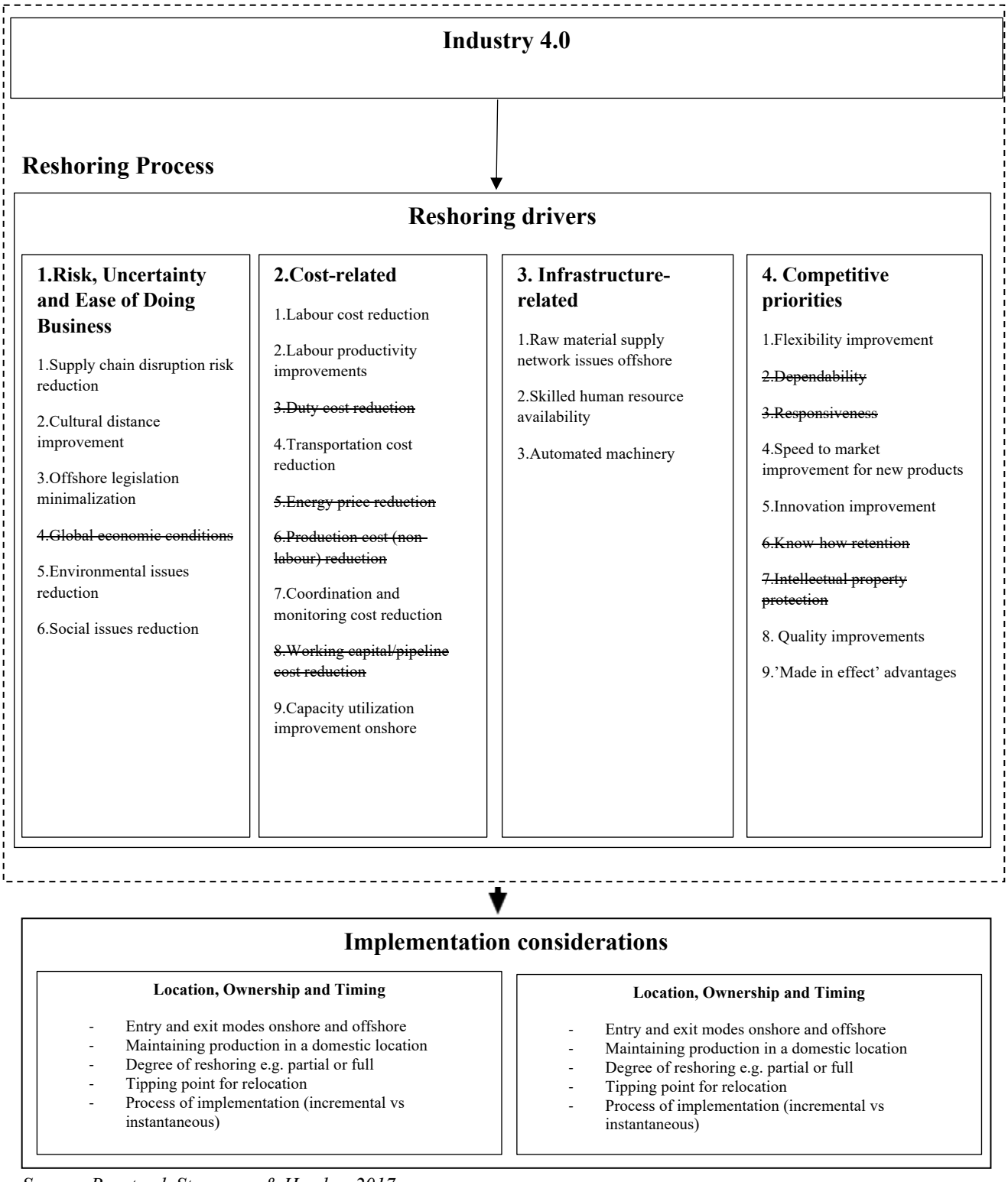
While this research has led to the surprising result that Industry 4.0 is an enabler for sustainability of businesses in the manufacturing industry, the managerial implications of these results have not been discussed yet. Therefore, a short follow-up study has been done by presenting some interviewees the abstract and conducting a brief follow-up semi-structured interview (Annex 3). This leads to the discovery that the implementations come with the following challenges:

- Sustainability in the manufacturing industry could lead to a shift in the entire business model: "*the moment you really start to think about implementing sustainable business models, you will have to redesign your entire business model, company and organization*". This quotation can be supported by the logical thought that sustainability changes the way of thinking about doing business throughout the entire organization.

- Moreover, daily practices for employees change: "*the employees in such a company would also have to do completely different activities… for example, a pattern maker suddenly has to work together with a designer in a different way, behind a computer*".
- Also, the consequences of implementing a sustainable way of doing business is paired by the dilemma of the trade-off between high costs and the risk of potential loss of customers. This can be seen as an interviewee stated "*sustainability goes through the entire chain ... but that is coupled with higher costs that customers do not want to pay for. Customers, however, expect the product to be sustainable, otherwise they will drop your brand. That is the big risk"*.

All of the above provides some insight into the effects and dilemmas that companies are currently confronted with. And therefore stresses the importance of further research for the possible solutions that Industry 4.0 could bring as an enabler of sustainability.

Figure 7 Framework of the Influence of Industry 4.0 on the Reshoring Process



Source: Benstead, Stevenson & Hendry, 2017

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Annex I. Informed consent and information sheet

Information sheet for
The Influence of Industry 4.0 on Reshoring

Author: Leonard Laseur

Last edited: 05-01-2019

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

Purpose of the research

The purpose of this research is to find new points of view on relocation decisions within the context of Industry 4.0. It may help managers to truly understand why or why not take reshoring decisions. As the research will be qualitative, it aims to find foundations to build a theory about reshoring decisions within the context of Industry 4.0. To participate in this research it is therefore also necessary (or you are planning) to have experience with Industry 4.0 and Reshoring.

This research has been reviewed and approved by the BMS Ethics Committee.

You have the right to withdraw from this research at any moment of time, without the necessity of providing a reason or any further consequences.

Any personal information that has been will be collected, will be anonymised for ensuring full confidentiality and to prevent the spread of competition sensitive information. The recorded interview will be transcribed and analysed for the sole purpose of the research. The processed data will be encrypted and saved offline in order to safeguard any personal information. You have the right to request access to and rectification or erasure of personal data. The anonymized data will be archived and used only for possible publishing and further research.

Contact details of the researcher are Leonard Laseur and his supervisor is dr. R. Harms, contact details of the BMS Ethics Committee to file a complaint.

Under the forthcoming General Data Protection Regulation (GDPR), consent needs to be affirmative.

Consent Form for *The Influence of Industry 4.0 on Reshoring*

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [DD/MM/YYYY], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I agree that my information can be quoted in research outputs	□	□
The goal of this study is to research the influence of Industry 4.0 on reshoring. Therefore it a sample criteria to take part in this research.		
Did you or do you have experience with Industry 4.0 and reshoring?	□	□
Use of the information in the study		
I understand that information I provide will be used for the entire research and any further publications.	□	□
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs.	□	□
Consent to be Audio/video Recorded		
I agree to be audio/video recorded.	□	□

Future use and reuse of the information by others

All of the data will be anonymised to ensure full confidentiality and to prevent the spread of competition sensitive topics.

I give permission for the *anonymized transcript* that I provide to be archived so it can be used for future research and learning.	□	□
I agree that my information may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.	□	□

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

	_____	_____
Leonard Laseur	Signature	Date

Study contact details for further information:

Leonard Laseur

Annex II. Semi-structured interview guide

Semi-structured interview Industry 4.0 and reshoring

Name:

Function:

Age :

Firm:

1. Qualitative interview introduction

Length: Approximately 45 minutes

Primary goal: To see things the way you see them… more like a conversation with a focus on your experience, your opinions and what you think or feel about the topics covered.

N.B. Develop consensus on talking points and common language that will be used (see paragraph 3 of this interview).

2. Background Information

Introducing Industry 4.0

What is your understanding concerning Industry 4.0?

Provide the used definition for this research:

Smart Industry uses ICT and new technologies. Smart by making products and machines interconnected and smart controlled. This does not only happen within one company, but also between companies and between companies and customers. Products, processes and services become smarter.

What is your understanding concerning reshoring?

Provide the used definition for this research:

Bringing back previously offshored activities to or near a domestic location, referred to as reshoring.

3. **Overview and starting point:**

Invite the participant to briefly tell about him/herself*:* General information about background of the firm. Mostly about experiences and perspectives on issues surrounding Industry 4.0 and reshoring.

Please describe your previous, current or future reshoring project.

If not mentioned please ask following information for the reshoring description vignette:

- What was/is the previously offshore location?
- What was the scope for the reshoring activities?
- How much turnover was there at the offshored location and domestic location?
- How many employees did you or do you have at the offshored and domestic location?

Please describe your previous, current or future Industry 4.0 project.

4. **Current state: Identify strengths/problems**

What does Industry 4.0 or did this mean for your reshoring project?

If so, how were the targets that were set for the reshoring achieved?

5. Current state versus required state

What topics are from your experience needed to be taken into account when preparing the Industry 4.0 planning?

What is from your experience the impact of Industry 4.0 on your reshoring decision?

If the following themes are not mentioned by the respondent, please include the following question(s)

Please tell from your experience of of Industry 4.0 and reshoring. What are your views towards (please cross out topics that have already been discussed);

- Risk and uncertainty, ease of doing business?
- Cost-related factors?
- Infrastructure related issues?
- Competitive priorities?

6. Analysis

Is there from your experience an existing best practice for the implementation of Industry 4.0 and reshoring? If so, how is that utilized?

What do you think is needed from your experience to ensure successful implementation of Industry 4.0 and reshoring?

What kinds of improvement proposals do you have from your experience in implementing Industry 4.0 and reshoring?

Annex III. Follow-up semi-structured interview guide

Name:

Function:

Age :

Firm:

1. ***1.*** **Qualitative interview introduction**

Length: Approximately 5 minutes

Primary goal: To get an understanding of the managerial relevance… more like a conversation with a focus on the evaluation of the results (see chapter 4), your opinions and what you think or feel about the topics covered.

N.B. Develop consensus on talking points and common language that will be used.

Summarizing results of this research

Provide the abstract of this research.

1. What are the implications of the findings of this study for the industry?
2. What could be the managerial relevance?
3. What is your understanding concerning sustainability in the textile industry?
4. What topics would need further research within the domain of sustainability?