Developing an Industry 4.0 framework: Implications for the role of line managers

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ABSTRACT

This paper explores the definition and components of Industry 4.0 as it seems to be a topic of much uncertainty and diversity. It does so to understand the effect of Industry 4.0 on the role of line managers. The research focuses on the EU and the streams of research that can be identified from the different member states. This paper discusses international literature in form of a matrix and a framework. As not much literature is available on the role of line managers in Industry 4.0, HR-expert interviews are conducted to learn more about this topic. The framework shows us that literature can be divided in four streams which discuss the technological, social, competitive and structural effects of Industry 4.0. On basis of this knowledge the experts evaluated the role of line managers as growing in complexity while it will experience support by the new technologies. In specific, Industry 4.0 is predicted to support line managers in tasks such as communication, leadership, giving feedback and decision-making. The findings of this paper will help companies with the preparation for and implementation of Industry 4.0. In addition to providing a clear definition and components of Industry 4.0, findings about the future tasks of line managers can be useful for recommending actions to companies concerning the training and teaching of competencies.

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1. INTRODUCTION

A few years ago, nobody would have expected this new organizational development to come. A big-data driven world, one in which the product communicates with the machines that produce it; a world in which robot-assisted production is part of an every-day business, a world that is wirelessly connected and that is fully automated (Li et al., 2017; Mayer-Schönberger & Cukier, 2014). Starting right now, we already see parts of this change in some organizations as it is challenging all our technological knowledge and standards, transforming them into a new unknown way. The described change is commonly identified as Industry 4.0. But what does the phenomenon of Industry 4.0 mean? How do line managers have to act in the new industry?

Before one can answer these questions, one first has to look at the history of previous industrial revolutions in Europe and their progress. This will influence our interpretation of the current industrial revolution and allow for predictions concerning the future of the European industry.

The first industrial revolution evolved in the 19th century. In this revolution steam- and water powered engines began to take over the work from employees, leading to a big resistance of change (Drath & Horch, 2014). This mechanization "left private homes in favor of central factories, followed by an extreme increase in productivity" (Drath & Horch, 2014, p.56). It took about a hundred years until the second industrial revolution took place. Drath and Horch (2014) describe it as "the development of continuous production lines based on both division of labor and the introduction of conveyor belts" that "resulted in another productivity explosion" (p. 56). This process is most known as the electrification of processes (Hermann et al., 2016). A result of this was the introduction of Ford's famous assembly line. Its introduction is still seen as a milestone within the history of industrial revolution, as it had major impact on job-design, leadership and production capacity (Ford & Crowther, 1922). As can be seen from this, the second industrial revolution required employees to adjust their skills to the new situation. Complexity and number of tasks increased, as well as completely new knowledge on all hierarchical levels was needed, to perform within the new technology (Chandler, 1977; Goldin & Katz, 1998). The third industrial revolution which started in the 1970s with the introduction of home computers (Haddon, 1988) is a "type of drastic social changes lead by the computerized mechatronics technology" (Kunii, 1997, p.1). This "programming paradigm still governs today's modern automation system engineering and leads to highly flexible and efficient automation systems" (Drath & Horch, 2014, p.56). Some researchers also name this revolution the "computer revolution" (Frey & Osborne, 2013, p.265) due to the increase of jobs that get performed by computer and other technological systems. Another change occurred concerning the skills needed from employees, now shifting attention to high technological-educated workers (Goldin & Katz, 1995). The previous revolutions did not only time-, but also technology-wise build upon each other (von Tunzelmann, 2003), leading to another change within the industrial landscape. It is important to see the transition between those very different technologies, to realize the need and impact of Industry 4.0. Additionally, the differences with former industrial revolutions can show us the distinctive features of this new Industry.

1.1 Industry 4.0 – A Universal Definition

Before defining what exactly Industry 4.0 is, it must be clear what exactly an industry is. This is not only important for the context of further analysis, but also needed to see the extent of change Industry 4.0 brings. For this paper the term *industry* is defined as a set of organizations who use Industry 4.0 to produce, service and compete on a national and international market. Based on this we can ask the question: What is so 4.0 on the future industry? What, based on what we know, does Industry 4.0 look like and what makes it different from its predecessors?

Industry 4.0 is, in its final state, the outcome of the fourth industrial revolution (Kagermann et al., 2013). While the first three industrial revolutions took together almost about 200 years to evolve (Drath & Horch, 2014), Industry 4.0 instead is "fast[ly] gaining ground and is carrying along with […] new enthusiasm […]" (Atzori, Iera & Morabito, 2017, p.135); it is fastly spreading (Lasi et al., 2014) around the globe. This speed makes it difficult for researchers to foresee what impacts Industry 4.0 will have on the global industry and how to control those (Brettel et al., 2014). Industry 4.0 is the term most commonly used in the Anglo-Saxon countries, even though other terms appear, such as Smart Industry (Dais, 2017), Industrie 4.0 (Bauernhansl et al., 2014) or Smart Factory (Ramsauer, 2013). All those terms contain different elements, depending on the author and the context they are written in. The context this paper focuses on are the different countries and member states of the EU. Throughout this paper different definitions, components and positions from these countries will be presented and compared. One view is that Industry 4.0 describes "the increasing digitization of the entire value chain and the resulting interconnection of people, objects and systems through real time data exchange" (Hecklau, 2016, p.2). While this is a very broad definition, other authors, like Hermann et al. (2016), identify specific components Industry 4.0 is consisting out of. For the writers, those are "convergence of industrial production and information and communication technologies" (p. 3928). These aspects can also be found in other literature (Kolberg & Zühlke, 2015; Shrouf, Ordieres & Miragliotta, 2014). The components are then most commonly known as (1) The Internet of things (IoT) (2) Cyber-Physical systems(CPS), and (3) Smart factory. Another researcher that gave a definition for Industry 4.0 was Kagermann (2015). For him the current industrial revolution is "characterized by a paradigm shift from [a] centrally controlled to decentralized production process" (p.23). We can find other formulations of that phenomenon in other papers (Almada-Lobo, 2016; Lasi et al., 2015; Rüßmann et al., 2015). There are researchers that define other parts of Industry 4.0: individualization, virtualization, hybridization and self-optimization (Aghassi et al., 2011) are just a few of them. All those areas seem to be strongly related to Industry 4.0 (Brettel et al., 2014), too.

Looking at all those definitions, a difference with the previous revolutions arises, namely that Industry 4.0 is announced before it happens. This gives researchers, managers and employees time to prepare and (where necessary) adjust towards the upcoming change a priori (Drath & Horch, 2014). To make use of this advantage a universal definition is needed that can give guidance and advise, by exactly stating what Industry 4.0 will look like and what one can expect from the new industry. The problem is obviously not to define Industry 4.0, but to find a universal definition, as the term is used differently in different contexts (Brettel, 2014). As can be seen, all the names and definitions are differing even though they are (unintendedly) referring to the same phenomenon. What they are all lacking, is to show similarities between already made interpretations and unifying them in one comprehensive definition. This already leads us to the added value of this study, as it brings together all these definitions. As can be seen later, many different components are getting identified but no definition covers them all. Therefore, this study does not just add another definition to all the other ones, but instead works on unifying all of them under one roof.

Such a definition is important due to multiple reasons. The first is given by Hermann, Pentek & Otto (2016) who state that "although Industry 4.0 is currently a top priority for many companies, research centers, and universities, a generally accepted understanding of the term does not exist. As a result, discussing the topic on an academic level is difficult" (p.1). But only with a clear definition that is derived from academical research, practitioners can adjust their work-style in the right way. To make it clearer: A well formulated conceptualization is needed before operationalization can take place (Quaglia et al., 2015). However, academic research can deliver much more than conceptualization. It can "fit real-world problems and settings into scientific method" (Bolton & Stolcis, 2003, p. 627), and based on this can give "clear, immediate, and important implications for managers" (p. 628). To enable these processes, a universal definition is needed. A second reason is concerning the pressure increasing globalization puts on companies, forcing them to work closer together than ever (Levitt, 1993). An "increasing global competition on product quality and production costs" (Brettel et al., 2014, p.37) is therefore requiring all companies to combine their research power and technological knowledge. But how should one work together if they do not even share the same definition of the ground principle? A last reason why a common understanding of Industry 4.0 is needed, lays with the uncertainty this industrial revolution brings with it (Schmidt et al., 2015). It is known that the new Industry will come, but nobody knows exactly how or when. To take this uncertainty of managers and employees, this paper will give a definition that allows to better prepare for the upcoming situation. From all the above the first research question of this paper evolves:

R1 What is Industry 4.0 and what are its components?

1.2 Industry 4.0 and Line Management

It is predicted that Industry 4.0 will not only have an influence on the economy in general, but also on daily business (Lasi et al., 2014). Therefore, I decided to not only give a definition of the term, but apply it to the role of line managers within the new industry, as they will be the ones closest to the new technology and its influence on work and workforce.

While barely involved in strategic decision making, one can say that line managers are the ones implementing the HR practices (Cunningham & Hyman, 1999; Hall & Torrington, 1998; Thornhill & Saunders, 1998). They do so by bringing the theoretical concepts to practice in every-day business. Next to this, nearly all HR policies need the action and support of line managers as they are the ones having direct contact with employees, influencing the "perceptions not only of HR practices but of work climate, either positively or negatively" (Ulrich et al., 1995, p.5). Thus, their behavior in implementing HR policies is important when successfully building social exchange relationships (Bos-Nehles & Meijerink, 2018). The authors Gilbert, de Winne and Sels (2011) developed a framework in which they describe the three core tasks, every line manager is responsible for in his daily work. First, the enactment of HR policies, second the development of relationship oriented leadership behavior and, third the creation of employee affective commitment. All of this shows the importance of line managers within an organization.

We can currently see a couple of management trends concerning the future role of line managers. Even though nothing is proven yet, several authors made assumptions about leadership (like Keegan & Hartog, 2004), the role of teams (like Fisher, 1999), control mechanisms (like Hawkins et al., 2012), the decision-making process (like Kwan et al., 2012), communication (like Welch & Jackson, 2007) and other management tools that will change in the new industry. Line managers will be directly affected by those changes, requiring them to adjust their management practices. If one takes a closer look at those, one can identify two major directions in the expectations for line managers. The first is the one that sees the role of line managers being supported by new technology, while the second one expects a substitution of line managers by this very technology. In the following I will present these to perspectives in more detail.

When it comes about supporting the work of line managers, communication technologies can be a big help (Kolberg & Zühlke, 2015). While in Industry 4.0, those technologies could allow bigger teams to evolve (Palazzeschi, Bucci & Fabio, 2018) they also require line managers to manage those in an efficient manner. This is, because so called *virtual teams* or *network teams* are often working together from different locations or even time zones (Lipnack & Stamps, 1999). It would be the task of line managers to organize and efficiently structure the new form of teams. Next to this, line managers would have to efficiently manage all the knowledge and data such a network brings with it. The effect of communication technologies can also be extended towards recruitment and hiring, as in Industry 4.0 line managers are likely to have to search for new workforce not only outside the company but even in other countries. Additionally, employees from all over the world will be able to apply initiative for a job, meaning that the recruitment process (and so the skills of line managers) must be adjusted towards the globalization of the work-force market. As can be seen here, Industry 4.0 increases the number and complexity of tasks line managers must perform.

As can be seen, Industry 4.0 is also expected to have a crucial influence on the needed leadership style, the way line managers motivate their employees and the decision-making process. As mentioned by Andelfinger and Hänisch (2017) the leaders of tomorrow are likely to show significant different personality traits. The five central ones, according to the authors, will be disruption, innovation, courage, social- and emotionally competence and determination. As new technologies allow for more and more connection between people all around the world, a challenge for line managers could arise, namely the problem of how to manage increasing team-sizes as well as how to lead people from more and various cultural and social backgrounds (Wuchty, Jones & Uzzi, 2007). Also, the general number of (potential) employees is assumed to increase (Lorenz et al., 2015), meaning that line managers, in the future, would have to manage more employees at once. Here the new technological developments are seen from a more diversified perspective. While on the one hand the level of leadership decreases, it requires less involvement of line managers, but the team size increases which leads to the fact that line managers are still needed for organizational- and coordinating matters.

On the other hand, it also seems possible that line managers will get obsolete at one point in Industry 4.0. Due to the increase of intelligent technology, it is expected that employees will get direct feedback about their performance from the machines they work with (TNO, 2017). This would diminish the need for line managers to "micro-manage" their employees, which is also known as "distant supervision" (Go, Bhayani & Huang, 2009, p.1). The relevance of the task of supervision might decrease, as line managers are already able to check employees' performance from anywhere at any time (Lee, Kao & Yang, 2014). Connected to this is the fact, that one goal of Industry 4.0 is the efficient

production of mass-customized products (Zawadzki & Zywicki, 2016), which would require supervision systems that are as efficient and fast as their corporate environment. This effect was also mentioned by Hales (2005) who found out that the role of line managers "has shifted from supervision to team leadership/co-ordination or business unit management" (p.1) and is expected continue doing so. From this we can see that new technology can actually take over easier tasks of line managers while leaving them with the more complex and inter-personal ones.

Another expected phenomenon that is often associated with line management in Industry 4.0, is the decentralization of decision making (Hermann, Pentek & Otto, 2016). This effect is assumed to lead to the forming of self-managing work teams. We can now already see a shift in companies to rely more and more on autonomous teams (Kirkman & Shapiro, 1997). Accordingly, it is expected that the number of self-managing teams will still increase. This new form of work teams "involves a shift focus from individual methods of performing work to group methods" (Manz & Sims Jr, 1987, p.106). On the long-term this would mean that there is a need for less managers, because supervision and directing tasks are performed by the teams themselves (TNO, 2017). The focus of line managers would be shifting towards coaching the team members to be more independent and work self-reliant, or as Manz and Sims Jr. (1987) call it "leading workers to lead themselves" (p.106).

As can be seen, multiple trends, about the future role of line managers, are identified. Many speculations are made about how their work might change and how this will influence the skills and knowledge line managers need to possess in the future. It currently seems possible that substitution as well as support of line managers is going to happen. It cannot yet be stated in how far these assumptions/examples are true, which creates uncertainty for line managers. There are two reasons why this report is attending to this uncertainty. The first reason arises from a scientific perspective. As can be seen from multiple search engines not much research has been conducted concerning the role of line managers in the future. In fact, only three search results appear, for the combination "Line manager" and "Industry 4.0" in Web of Science, and forty-three when using Google Scholar (status of 18/04/2018). However, as shown earlier, line managers are playing a key role in an organization's success and should therefore be analyzed in more detail. A clear definition has not been given yet, but it is needed because other researchers can then build on the result of this analysis, going into further details, and also give concrete practical advice. The second reason comes from a practical point of view. As it is expected that Industry 4.0 will have a huge impact on technology as well as on whole production processes (Lasi et al., 2014), it seems worthy to look at those who will have to deal with the new Industry directly. This research can be used to inform and coach line-managers, concerning their future position and task within Industry 4.0. Based on this, training sessions can be developed that prepare line managers for the coming industry and that communicate new skills and competences. The goal of this research therefore must be the examination of the role that line managers are performing daily, within Industry 4.0. The derived second research question will be:

R2 What is the role of line management within Industry 4.0?

2. METHODOLOGY

To find an answer to those questions, an explorative-qualitative research is conducted. It is explorative due to the limited information given about Industry 4.0 and its influence on line managers. The focus of explorative research is "on the discovery of ideas and insights as opposed to collecting statistically accurate data. That is why exploratory research is best suited as […] it is most commonly used for further defining company issues, areas for potential growth, alternative courses of action, and prioritizing areas that require statistical research" (FluidSurveys Team, 2014). Stebbins (2001) adds to this by defining exploratory research as "a broad-ranging, purposive, systematic, prearranged undertaking designed to maximize the discovery of generalizations leading to description and understanding of an area of social […] life" (p.3.). One could say that exploratory research is necessary for this research, as one goal of it is to point to the necessity of finding a universal definition of components of Industry 4.0 - an area with potential growth. Next to this, exploratory research is most effective in laying the groundwork that will lead to future studies.

Qualitative research is conducted where literature is used "to understand what is going on in the field and to discover theoretical perspectives, including proper concepts to look at the social phenomenon of interest" (Boeije, 2010, p.5) Reflecting on this, one can see that it is exactly what this report needs, as it tries to develop a universal framework for Industry 4.0. Qualitative research is also used in cases where theories, frameworks and, in general, data, is limited (Boeije, 2010). By trying to find out more about Industry 4.0 and its implications for line-managers this paper does not have much research at hand, that it could use. Qualitative research gets conducted by "means of semi-structured measuring instruments that are searched and tailored to the research subject and refined as the research progress" (Boeije, 2010, p.5). This research is doing so by adapting the interviews towards the limited knowledge of the experts, helping them out with a self-created framework about Industry 4.0. In qualitative research theory, there are no existing frameworks that can be used, meaning that the researcher cannot build his study around already existing knowledge, but instead has to come up with his own hypothesis (Boeije, 2010). For Industry 4.0, not much theory is developed, therefore requiring me to make use of qualitative research. In such, "inductive thinking is paramount, which means that a social phenomenon" (here Industry 4.0) „is explored in order to find empirical patterns that can function as the beginning of theory" (Boeije, 2010, p.5). It should also be added that qualitative research is conducted, where the researcher believes that that individuals have the power to influence the construction of social reality (Dooley, 2001). In our case, this can be seen in the fact that one goal of this paper is to draw attention to Industry 4.0 and the chance to control it, if researchers and practitioners start to plan the future of the industry together.

To answer the research questions mentioned above, this paper is divided in two parts of research. The first one is answering the question (R1), about the components and definition of Industry 4.0, using comprehensive document analysis. The second one, that deals with the other question (R2), concerning the role of line managers, will be answered by conducting interviews with HR experts. In the following I am going into more detail about how and why the research is conducted.

As mentioned beforehand, there is not much research literature available that is concerning Industry 4.0 and the role of line-managers in it. That is why this research is dependent on the documents of a wide range of sources. To outweigh this lack of information, this research is taking a mix of policy documents into account. Next to this, the analysis will include more than one country. Additionally, to the Netherlands, these will be Austria, Belgium, Germany, Denmark, Hungary, Italy, Lithuania, Luxembourg, Portugal and Sweden. These countries were chosen

as they are all part of the EU, which is important and will be mentioned in more detail later. Next to this, all these countries provide online information (in English) about their national research concerning Industry 4.0. The focus was laid on policy documents from the national research agencies as it was found that definitions highly differ between countries. So, to be able to compare definitions and components of Industry 4.0 in different countries it is necessary to look (only) at the data provided by governmental institutions. Additionally, the chosen countries function as a good representation of Europe, as they are various in culture, economy and politics. Other countries that are not considered here are either collaborating with one of the above-mentioned ones, are not conducting any research in the field, or are working on a similar definition. This research depends on the availability and reliability of the online documents the countries present, as academic papers are rare, and there are no other official sources that can be used. All in all, the conducted literature review is not structured, as findings and information will evolve during the research process itself. Just at the end of the process we will be able to reflect on what was found and can then formulate a clearer definition. The decision to focus on European countries has two reasons. The first one is that, as shown before, there is simply the necessity for a comprehensive definition within Europe, as every country is using different terms and identifying different complements of Industry 4.0. This is due to all the separated, national research projects (such as *Smart Industry* in Sweden, *Indústria 4.0* in Portugal or *Made Different* in Belgium). Europe is consisting out of many countries with diverse cultures, anyways, European countries are connected through the EU and other political institutions and regulations. Based on this, one can say that all countries are facing the same situations. When looking at Europe, all countries together, form a big picture of possible components for Industry 4.0, showing a lot of diversity. Analyzing Europe will allow me to give a holistic statement about the components of Industry 4.0, for many different countries at once. On the other side, a European focus still allows to compare the countries on cultural core values. Due to the EU, many laws and regulations are the same. This shared base makes it attractive to analyze Europe as it will make the document analysis more structured and reliable. The second reason is that Europe, and especially the EU, is one of the biggest players on the world market and belongs to the most developed areas when it comes to technology (Pomeranz, 2009). While there are of course also other countries in which technology gets developed, it is difficult to find such a concentration of technology-advancement on a comparably small geographical area. The country specific information is retrieved from a list of links, posted by the European Commission on its website about national initiatives that are actively researching Industry 4.0 and any other related topics (European Commission, n.d.). The linked websites are maintained by either the government or a consulting company, that is conducting research for the according government. The document analysis is conducted together with two fellow researchers (ten Bulte, 2018; Tekelenburg, 2018). To allow future researchers to better evaluate on this analysis, we created a matrix. The analysis was conducted by going over the website of the European government who provides links to the webpages of the national research agencies. To filter relevant information, the search function was used to look at relevant phrases like '*Industry 4.0', 'Definition', or 'Components'*. By doing so, the documents were analyzed and relevant information was set into the matrix. Later on, the information was sorted in columns that evolved, like the country of origin of the analyzed document, what definition and components of Industry 4.0 it delivers, whether the author created his own definition or rephrased another one, and what implications the author predicts Industry 4.0 to have on line managers. The matrix was divided like this, as all the information is needed to be able to give a comprehensive definition. Therefore, the following results are received by inductive coding which "refers to approaches that primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher" (Thomas, 2006). This sort of analysis is used as I start with an area of study and then let the theory evolve from the data I found (Strauss & Corbin, 1998). In this case that means to learn about Industry 4.0 from the policy papers, and then concluding in a framework that includes all the components which are analyzed in the different countries of the EU. By showing the country of origin, one can see possible trends per definition throughout Europe (e.g. via geography or economy). The rest of the columns, are self-explaining as they are answering directly to the research questions. The matrix can be found in *Appendix 1 – Literature Matrix*. In total around 70 documents get analyzed of which 38 can be found in the matrix. The reason why some of the documents were not taken into further account, was that they either did not contribute enough new information, were not available in a language I speak or were simply so vague that they could not be used in formulating a clear picture of the countries definition of Industry 4.0. By using this matrix, I will be able to say what Industry 4.0 is and define which components form the basis of it, by creating a framework.

For the second part of my research I decided to conduct expert interviews. Conducting interviews supports the "true understanding of what is happening" (Boeije, 2010). Interviews are "a form of conversation in which one person – the interviewer – restricts oneself to posing questions concerning behaviors, ideas, attitudes, and experiences with regard to social phenomena, to one or more others – the participants or interviewees – who mainly limit themselves to providing answers to these questions" (Maso, 1987, p.63). The option of interviews was chosen as they give the researcher insight into the perspective and experience of experts. Since Industry 4.0 – as an end-state – is not reached yet, expert opinions will help to give a prediction for the future. For the success of interviews, it is crucial that both parties are educated in the knowledge domain the interview is about (Boeije, 2010). The six interviewees for this research will be professors and research assistants in the field of HRM, from multiple Dutch and Belgian universities. The interviews aim to obtain advice about the role of line managers within Industry 4.0 on basis of the framework created beforehand. HR experts were chosen because they do not only have specific knowledge about the research topic but also years of theoretical and practical experience, which increases the value of their statements, making them the most reliable source of information. The experts do not need to be experts about Industry 4.0 as they can build on the framework of this paper. This also allows me to compare the answers of the interview as they are then built on the same ground knowledge. Still, two of the respondents have a research focus on the interaction between technology and HRM, which makes them an even more valuable respondent. It was decided to focus on Dutch and Belgian experts, due to the limited amount of time that can be spent on data collection, so that conducting interviews will not cost too much resources. Further, it was decided to find experts via this network due to the good connection with the HR department of the University of Twente. This made access to the experts quicker and easier. The Dutch HRM Network's mission "is aimed at stimulating fundamental and societal relevant scientific research in the field of the employment relationship" (HRM Network - Mission, n.d.). Looking at this, we can see that members of this network can contribute a lot to our research, as the network is focused on working on societal

relevant topics. Industry 4.0 certainly is such a topic, as it is expected to have a huge impact on different parts of society. The network consists out of experts and researchers from ten Dutch and Belgian universities, who's goal is the coordination of HRM research (HRM Network - Objectives, n.d.). I think that members of this network can add value to my study as they are also focused on finding holistic perspectives about HR related topics. As all members of the network are having an HR profession, the decision on whom to choose for the interviews, is based on past research, the general research focus and availability of the respondent. Based on the framework created under '*Results I – Literature Matrix'*, the chosen experts will assess potential roles line managers might play in the future. As the experts are mainly educated within the HR field of business, their evaluation is dependent on the picture of Industry 4.0, drawn in the first part of this paper. The interviews are scheduled for an hour and are recorded and later on transliterated. When analyzing the transliteration, I hope to find certain patterns in the answers of the respondents which I will then group and sort under a fitting heading. The transliteration itself will not be sent to the respondents, but they will receive a copy of this paper as soon as it is finished.

3. RESULTS I – LITERATURE MATRIX

To receive more information about the definition and components of Industry 4.0, as well as the implications it might have on the role of line managers, a matrix was created. The matrix is a summary of all the literature that was found online from the webpages of the country specific research associations of the European Commission concerning Industry 4.0 (*Appendix 1 – Literature Matrix*). All in all, the matrix represents policy data from more than ten countries and many and various sources, making it a complex and detailed overview. Next to country specific information regarding the definition and components, one can find more material about the research focus and other important remarks.

When looking at the matrix one can see how many different definitions, components and assumptions about influences of Industry 4.0 are existing. Definitions between, but also within countries, are varying in content, complexity and commonality. All definitions together show the complication of the topic and the possible impact it might have on many and various business areas. Still it can be said that most of the time, definitions stay weak and unclear, only giving vague statements about what might come, instead of clearly naming components of Industry 4.0. Next to this, no literature of other authors is being considered or used as comparison. This exacerbated my research a lot, making it difficult to conclude a valid definition. Despite all the unclearness and differences between the countries, several streams can be identified, helping to get a clearer picture about the components of Industry 4.0. To visualize the content of the matrix and streams, it was decided to create a framework that provides an overview of the different directions within Industry 4.0 (see Figure 1).

The streams are different perspectives and evolve when analyzing the matrix. They are dealing with different foci and roles Industry 4.0 might perform in the future. The streams were identified by looking at repeating patterns in the definition- and component- column of the different countries. The definitions then got grouped and were given a holistic name, that summarized all the terms in an appropriate way. It was found that none of the countries only fitted one of the described streams. Instead, it showed that the more literature available per country, the more diverse the research areas became. Some countries are researching in all four directions, while other countries only focus on two of the streams. This shows that also the extent of research differs per country. Interestingly it was found that also within a country the research focus can vary. Countries that started earlier with looking into Industry 4.0 are more likely to cover a broad (technological) spectrum of the topic. Inspired by the work of Habraken & Bondarouk (2017), which described different enablers and characteristic features of the Dutch Smart

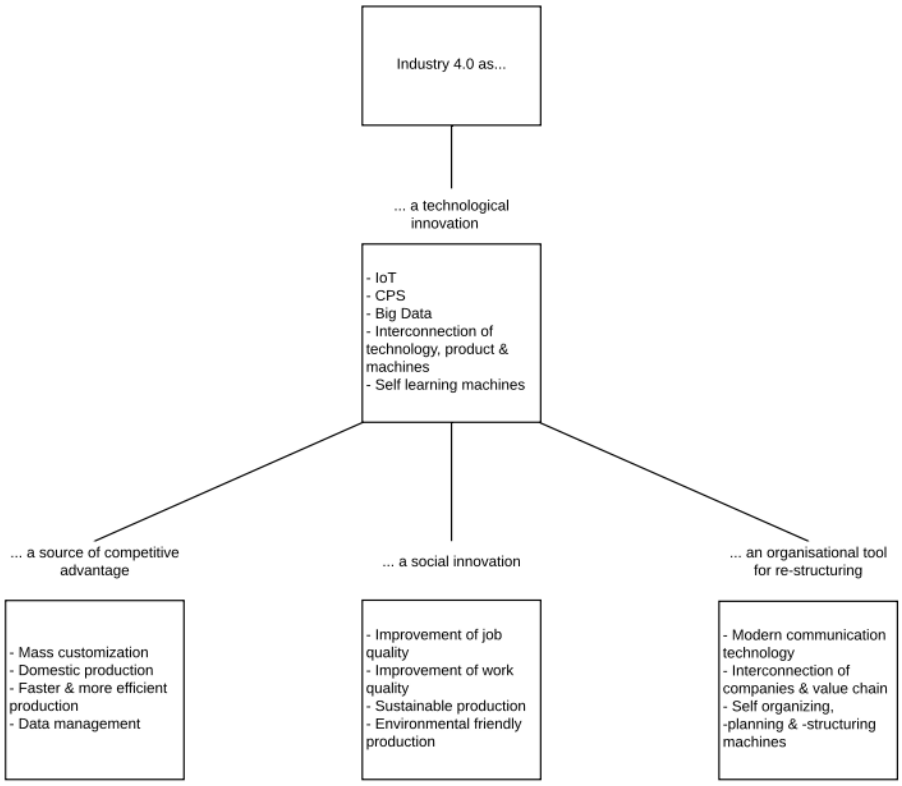

Figure 1. Framework of Industry 4.0

Industry, I developed the framework as you can find it here. My framework is structured in a hierarchical way. It starts with the term *Industry 4.0* on the top. The four streams are then following on two more levels. On the second level of my framework one can find the stream of "Industry 4.0 as a technological innovation". The reason for this is that when analyzing the literature, it was found that the idea of new technologies in the value-chain is the starting point for any research. One could say that the technological structure is the basis for the other (more advanced) streams, and therefore must be presented in a more outstanding way. This stream is then followed by the streams of "Industry 4.0 as competitive advantage", "- social innovation" and "-organizational tool for re-structuring". Those three subordinate streams do not follow a special order, as we can find all of them, mentioned an equal amount in the literature. Please note that this form of hierarchy is not used to indicate that the last three streams are less important, but to show that they are playing a role later in the research process. In the boxes under the name/research focus of the stream, one can find components that came up in the literature. In the following I will describe the four streams of Industry 4.0, explain their impact, give example of countries per stream and explain how this contributes to a comprehensive definition.

3.1 The Four Streams of Industry 4.0

The first stream is solely focused on the new technologies that are part of, but also are the result of Industry 4.0. While one can certainly find starting points of other matters (such as social, environmental, or legal), literature in this stream is mainly working on a clear description of changes in the technology sector and focusses on giving advice to engineers and other people that will be directly involved in creating and designing the new industry. This stream therefore expects Industry 4.0 to be a pure technological innovation. In comparison to other streams, the focus of research lays on individual technological accomplishments. The countries most often associated with this stream are Austria, Germany and Denmark. The components frequently named in this stream are the Internet of Things (Pagegroup, 2018; Silkroad 4.0; 2017; UEL, n.d.), Cyber Physical systems (Lassnig et al., 2016; Ericsson, n.d.), Big Data (Deliége, 2017; Stentoft, Rajkumar & Madsen, 2017; Silkroad 4.0, 2017), as well as the creation of self-learning machines (Pagegroup, 2018; Danish Institute of Industry 4.0, n.d.; Federal Ministry for Economic Affairs and Energy, 2017). Additionally, we can see some other technical concepts such as the one of Virtual Reality (VR) (Federal Ministry of Economic Affairs and Energy, n.d.) or 3D (Stentoft, Rajkumar & Madsen, 2017), but they seem not to be part of the core of this stream. Next to this, throughout all literature a trend towards the interconnection of technology, machine and product can be identified; most often combined with the terms of IoT or CPS. Because all countries in the matrix are talking about technical features and build the rest of their research on these findings, this stream seems to be the most known and common one. It also is the one most talked about, as one can deduce from the matrix. This might be traced back to the technical origins of Industry 4.0, which build the basis for all other type of research, but also to the fact that forecasts about future technologies are easier to make than an analysis of its impacts on social, environmental or organizational matters.

The second stream focuses on a country's own economy and the profit one can derive when applying Industry 4.0 to production. Further, Industry 4.0 is here seen as a source of competitive advantage. One could say that research in this stream focuses on generating economic value. The literature of this path is focusing on the effects of mass customization (Sirris & Agoria, 2016) and the way new technologies can improve production (Association Industry 4.0 Austria, n.d.). One important effect of Industry 4.0, described in this stream, is the stop on moving jobs abroad by creating new, high qualifying jobs in the domestic countries (Silkroad 4.0, 2017; Sirris & Agoria, 2016). As the new technologies are allowing for a cheaper and more efficient domestic production, outsourcing jobs to other countries will get less attractive. The authors expect that by producing high value-adding products on a high scale, the number of sales can increase, and ultimately result in a higher profit. Globalization is a topic often discussed in the literature of this stream, most often connected with the problems it contains for employers and employees. Not surprising is that the countries in favor of this stream are those who's economy is currently facing a crisis (Leon & Pavolini, 2014; Anna et al., 2015; Petmesidou & Guillen, 2017). The countries that showed clear tendencies towards this stream were Portugal, Lithuania and Italy. This can be seen in statements of the countries such as "repatriation of production from east Asian countries to Europe" (Silkroad 4.0, 2017) or "to help […] for an even more competitive 'Made in Italy'" (Ministero dell'Economia e delle Finanze, n.d.). Nevertheless, one can find this competitive thinking also in other countries. Luxembourg, for example, talks about its "future competitiveness of industrial companies in the western world" (UEL, 2017). On the other hand, some literature identifies an increase in the will of people to work abroad (Pagegroup, 2018) and connects this with Industry 4.0 and globalization.
It seems as if all countries want to take the opportunity of Industry 4.0, and make it work in their favor. This shows once more the disruptive change the new industry might bring, and the chances connected to this. From this we can see that Industry 4.0 does not come without problems. It goes hand in hand with the increased pressure of globalization on the countries, forcing them to generate high economic value which turns the world's industry into a place where every country must fight for surviving.

The third stream focusses on the possible effects Industry 4.0 might have on employees and/or the environment. Generating social and environmental value is the main objective. I call this the stream of Industry 4.0 as a social innovation (in some literature also mentioned as political innovation). Literature that is concerned with the social impact of new technology deals with the fact how the work environment for employees might change due to new technologies. Next to this, sustainable and environmental friendly production are standing in the center of research. Countries that are putting a remarkable amount of their research into those topics, are Belgium and Sweden. While the latter one especially considers the effect Industry 4.0 might have on environmental production, allowing for sustainable, conservative resource usage (The Swedish Trade & Investment Council, n.d.), the former considers Industry 4.0 as an option of creating a workplace that is not only creating satisfaction for employees, but also leads to a better productivity through changes in the job market and work tasks (Sirris & Agoria, 2016). By changing tasks, labor could be reduced, so employees would work in less physically intense jobs. Next to this, some literature states that employees should not only be informed, but also actively involved in the process of introducing Industry 4.0 (Sirris & Agoria, 2016). I observed that not many countries are keeping themselves busy with researching for sustainability of the environment in the future, but that more and more countries start looking into the effects of Industry 4.0 on workplace environment and job satisfaction. We can see this for example in Denmark and in Germany. Nonetheless, the topics of this stream seem not to be of interest till a later part in the process of analyzing Industry 4.0. We can see that countries, who are already researching for years about Industry 4.0, are getting more and more interested in these topics in comparison to countries

who just started their analysis and focus on the technical aspects of the first stream instead. This does not mean that social/environmental aspects are less important for researchers, but that a detailed description of the technological aspects of Industry 4.0 must be preliminary to those aspects.

The last and fourth stream is representing a non-popular thought about Industry 4.0, namely Industry 4.0 being an organizational tool for restructuring. As all the other ones, this stream looks at the effect Industry 4.0 might have on businesses but instead of focusing on profit, people, or the environment, literature in this stream looks at how exactly the new technologies will influence the structure and organization of a company. Communication technologies therefore play a crucial role (Keil et al., 2001). But also other technologies, such as self-organizing, -planning and -structuring machines (Federal Ministry for Economic Affairs and Energy (2017), are taken into account. These new technologies are seen as having the potential of noteworthy influencing an organizations structure. One important difference to other streams is the focus on interconnection, not of technologies, but of companies and the value-chain (Danish Institute of Industry 4.0, n.d.). These interconnections, that are influenced by technological change, might force organizations to adjust and adapt their structure. Literature from this stream most of the time also includes implications for line managers, as the changes in structure and organization directly influence the work of line managers. This is most acknowledged by countries like Hungary and Luxembourg.

When comparing my findings with the research of Habraken & Bondarouk (2017), I can find many of my points back in the Dutch Smart Industry. Digitalization, connectivity, value chain participation and personalization are just a few points the researches have in common. Nevertheless, some of the points that seem to be a part of the core of the Dutch Smart Industry could not be found back in the literature. I especially could not find any proof for the impact of cyber security and other safety matters that the researchers found during expert interviews. Still some papers, like the one of Hermann, Pentek & Otto (2016), talk about this topic, but then describe it as a more separated technology, which is why I did not include it in my framework. We at least cannot find back this topic in the discussion around Industry 4.0 on a European level.
So, after all of this, what is Industry 4.0, and what are its components? The definition is based on the interpretations and components, identified in the matrix and framework. A comprehensive, European definition would, therefore look like the following:

Industry 4.0 is the production, service and work context in which new smart technologies and the overall digitalization of the value-chain are used. As such, Industry 4.0 is the end-state of changes in the national and international competitiveness of firms, by allowing them to re-structure their business in a social, technological and environmental responsible way.

3.2 Implications for Line Managers

As one can see from the matrix, not many implications for line managers are given in the international literature about Industry 4.0. This does not only fit our previous expectations but once more shows the necessity for such research.
The findings about the role of line managers in the new industry can also be structured into the four streams of Industry 4.0. However, some streams focus more on line managers than others. In the following I will discuss the different streams, starting with the one that contributes most.

The fourth stream of Industry 4.0, the one that sees it as an organizational re-structuring tool, delivers the most information when it comes about line managers. Literature of this stream did not only mention how new technology will change the structure of the organization, but also how exactly work for employees and line-managers will change. One example is the article of the German Federal Ministry of Economic Affairs and Energy (n.d.), who is considering the new communication technologies. The article concludes that a "convergence of office-floor and shop-floor communication" will occur, and that it is the task of line managers to coordinate the new ways of communication with the everyday-business of the firm. Another topic discussed in this stream is the type of leadership Industry 4.0 will require and what kind of behavior line managers should foster. The Union des Entreprises Luxembourgeoises (UEL) (n.d.), says that in Industry 4.0 it will be crucial to promote independent and creative work behavior among employees. This can either be done by training/workshops/coaching or by the creation of jobs that require employees to act in the requested way. All of this are tasks and responsibilities of line managers, which shows us the importance of line mangers in Industry 4.0.
The second stream, the one of competitive advantage, specifies on the lack of skills, companies will face when entering the new business-phase. Throughout all literature, it can be seen that employees will have to learn new skills to make the business run efficiently. The literature speaks then about "interdisciplinary-" or "digital-" training and skills development (Lassnig, 2016; Ministero dell'Economia e delle Finanze, n.d.). The new acquired skills must be communicated and trained by line managers, who are in the position of scheduling and planning training sessions. They therefore need to prepare their employees to work with the new technologies. Still, the preparation and training of employees and self, for line managers, seems to stay vague when talked about. In multiple literature we can find hints about the necessity for such training methods, but none of the sources talks about a detailed training plan or names technologies that might be used in future training. Some technologies that are expected to have a huge impact on the type of training, line managers and their employees will have to follow, are virtual training (Kozak et al., 1993), simulators (Hammerton, 1967), smart watches (Porzi, 2013), data glasses (Rüßmann et al., 2015) and digital dashboards (Baskett, LeRouge & Tremblay, 2008). The technologies are most often developed on the idea of 3D and augmented reality (AR) (Lee, 2012). Still, those technologies were not discussed on the internet pages of the research institutions of the EU member states. It appears that the goal of using these technologies is foremost to bring the change of job and tasks into employees' consciousness while on the other hand trying to avoid mistakes in production as soon as the new technologies come into place. It must be seen, if during the interviews with HR experts more information about such technologies in combination with training will come to light.
When looking at the third stream, "Innovation 4.0 as a social innovation", the literature does not give a lot of advice about the role of line managers. Even though multiple sources of information are picking up on the increased level of control new production systems create, only one of the analyzed sources is going into more depth about the problem this might create for the employee-line manager- relationship (Federal Ministry for Economic Affairs and Energy, n.d.). We can see from this that the control tasks of line managers are subject of change, but we cannot say more about this based on existing literature.
The first stream of Innovation 4.0 did not deliver much insight for line managers. The papers of this stream instead focused on the new technologies that are coming, but missed to link those with the role of line mangers.

All in all, we can summarize that, as expected, the policy documents about Industry 4.0 did not deliver much about the role of line managers. There were some hints to find about the social and organizational impact of Industry 4.0, for which line managers will play a crucial role but still this did not give us enough information to draft a possible role of line managers.
Therefore, additional interviews with HR experts are conducted, in hope that they will contribute more to the second research question.

4. RESULTS II – EXPERT INTERVIEWS

To solve this question and to get a better insight in the role of line managers, I decided to conduct expert interviews with members of the Dutch HRM Network. You can find the questions attached (*Appendix 2 – Interview questions*). From the interviews, I got a good insight in the possible role of line managers in Industry 4.0. Even though all interviewees focused on different aspects and tasks, it was possible to find some overlap in their answers. In the following I will present the major topics that got discussed during the interviews and I will reveal certain similarities and differences in the assessment of the role of line managers.

While listening to the interviews, certain roles of line managers got described. In general, it is expected that a shift from current HR tasks will take place, downwards the hierarchy to line managers. This leads to an HR department which fulfills solely strategic tasks on the one hand, and line managers who are responsible for the supervision and administration of the company on a daily basis, on the other hand. So, it can be said that the experts predict the role of line managers to increase in complexity and difficulty. Nevertheless, a discussion arose about how the new technologies are going to influence the work of line managers. The discussion turns around the question whether technology should be used to support line managers or to substitute them. This can also be found back in a practical context, where for example Airbus and Boeing are presenting the role of line managers in the future completely different. During the interview we heard experts from both sides of this spectrum, arguing about what will happen to line managers in the future.

One role that got described, is the one of line managers as decision makers. As described earlier, a current task of line managers is the support of the HR administration by bringing HR to practice and making decisions concerning the outcome of the business, while at the same time maintaining the well-being of the employees. In the future it seems that this decision making can be improved and supported by all the new matters of technology. In many interviews the term of HR analytics was named, especially in relation to big data. By getting new insights and more detailed data about their employees, the HR academics expect that decision making can be improved and made easier for line managers, as in Industry 4.0 it will be possible for them to reason their decisions not only on a guts-feeling way, but to proof it with valid data.

Next to this, another important role of line managers will be to play the communicator in a company. A line manager will therefore not only be responsible for communicating the HR strategy anymore but will also have to take their employees by the hand and show them the advantages the new technologies will bring. It is therefore important to also dive into the uncertainty employees might experience when getting in touch with the new technologies. This will be highly influenced by the new communication technologies that the respondents described. Those technologies will help to increase the frequency and amount of information that can be passed on between line managers and their employees. Still, all respondents point out the importance of face-to-face communication, as none of the respondents can imagine that Industry 4.0 will work without any direct personal contact, let alone the replacement of face-to-face communication.

> *"Face-to-face communication will never be replaced, just because it is a richer medium to communicate"* (Expert 1)

During the interviews it was additionally found that, due to the flattening of organizations, the relationship of employee and line manager will significantly change. Due to an increase in autonomy and the additional possibilities to supervise employees through data, some of the experts forecast a more distant relationship, while others suggest that due to an increase in self-managing teams and shared leadership, the relationship will actually move to a more equal and close-related tie. This is also often argued because of a possible increase in interdependency in tasks, caused by Industry 4.0. Nevertheless, there are experts that are saying that the relationship will not change at all. These are also the experts that do not see a strong correlation between Industry 4.0 and line managers. What all respondents could agree on was that it will remain the task of line managers to maintain the social relationships with their employees.

When interviewing the experts, I also heard a lot about the certain personality traits a line manager in the future should have. Most often the respondents named openness to innovation and a high interest in people-management as critical attributes. Still, you could see some differences between the answers. While some respondents focused on the empathy, others looked more into the organizational talent or the leadership skills. Thus, the personality of a line manager that is needed to perform well in Industry 4.0, has to be very various, complex, flexible and live up to many different expectations.

Anyways, during the interviews also certain challenges seem to evolve for the role of line managers in Industry 4.0. The biggest challenge that line managers will have to deal with, will be the upcoming labor shortage. As line managers will also get a stake in the recruitment process in the future they will have to fill vacancies with workforce that has the required knowledge and skills to fulfill the needed tasks. From the interviews I learned that for the future the experts foresee a mismatch between the skills organizations require and the skills which the educational system teaches the future employees. Therefore, it is predicted that organizations, and especially line managers, will play a major role in teaching and training employees. Still, the questions on how and what exactly to train is not clearly answered. When training the employees for and in Industry 4.0 it is likely that line managers can hark back to new technologies like virtual reality, simulators or 3D. Anyways, some respondents stated that those technologies are not new anymore and so are not linked to Industry 4.0. However, they did agree that those technologies will still be used in Industry 4.0 and will not be replaced by then.

> *"Nevertheless, the problem remains what kind of education and what kind of training is needed"* (Expert 6)

Another challenge that came up during the interviews was the problem of the increased flexibilization of work. Here the opinions of the experts differ. While some still foresee an increase in flexibilization some others saw a "pendulum" coming back already, meaning that certain work styles such as home-office and 24/7 reachability, is already outdated and will decrease in Industry 4.0. Line managers therefore might have to cope with many different working styles in the future. It will be their task

to coordinate them and to find a way that brings together all different types of needs of their employees within one organization. One example named more often was the individualization of rewards, by which line managers will have to adjust their payment and reward systems to the individual. Some experts also see that flexibilization is getting even more complicated due to the communication technologies of Industry 4.0 that for example allow virtual teams. One respondent even sees this as a paradox, as, due to technology, more and richer communication is becoming possible, while at the same time less communication is needed due to individualization of work.

One last challenge the respondents saw, and which especially seems to play a major role in the process of change, is culture. As pointed out most often by the respondents with a psychological- or social-research focus, culture is a subject that is difficult to change. As Industry 4.0 seems to relate to a high level of uncertainty, the resistance of culture to change gets even increased. From the interviews it can be concluded that it will be the role of line managers to "break-open" the old culture and to create a new one that includes all the components of Industry 4.0. However, as mentioned by one respondent, it is not just done by implementing the new culture; it must be sustained and kept.

> *"Before you can learn something new you will have to unlearn the old"* (Expert 3)

Please notice that for nearly all my conclusions also an opposite point of view was presented. In only a few of the topics all experts were of the same opinion, making it difficult to lead to holistic conclusions. The results, as presented here, are based on which opinion overweighed. Next to this, I also noticed some critic on the framework that was presented to the respondents and on which they were supposed to build their opinion. Some of the respondents, believed that some of the components of the framework were not really related to Industry 4.0. Even though the framework is built on a solid literature review it seems that still not all opinions on Industry 4.0 are covered in it. In general, it can be said that still much uncertainty concerning line managers in Industry 4.0 exists. It seems that nothing is fixed yet and that in the end the role of line managers could still go different ways. So, while some experts see the role of line managers gaining value in Industry 4.0 others do not see a big difference to the current state. This is why it is so difficult to train and prepare line managers in the needed way, as the opinions about which skills to train and how to do so are not unanimous. Nevertheless, the general forecast for line managers in Industry 4.0 is positively and gets often described as very important and indispensable. In the end, it seems that it all depends on the country, industry and company the line manager will have to perform in. This all allows me to conclude in an answer to my second research question. The role of line managers in Industry 4.0 can therefore be described as the following:

Line managers in Industry 4.0 will not only be responsible for leading and communicating the implementation of the new technological components within the production- but also within a social- and psychological context. Training, coaching and supporting his employees will be a line managers most important task. Further he will gain more administrative and analytical responsibilities which are ultimately increasing his decision-making power. The role of line managers will require proactive and anticipating behaviour as well as a high level of social and technological knowledge.

5. DISCUSSION

5.1 Industry 4.0

Much can be learned from the findings of this research; for Industry 4.0 as well as for the role of line managers.
In the beginning of this paper I described Industry 4.0 as a mainly technological change. After conducting the literature review it gets clearer that Industry 4.0 is way more than just new technological accomplishments. Even though they are still forming the basis of European research, other areas, such as social, competitive or organisational, seem to play an important role in the future. Still, it can be said that the earlier identified components, such as IoT, CPS or Big Data, could be traced back in the literature. From this we can generally say that there are big differences within the research of Industry 4.0 between the states of the EU. Next to this, the general assumption that Industry 4.0 would have a high influence on production seems about to be right. Anyways, what was not part of earlier predictions is the influence of Industry 4.0 on other areas of life next to the production. Now one can see that the whole value-chain will be affected. As a reason for this the literature often names globalization, whose influence was already predicted earlier. I now know that it is difficult to give a holistic answer to the question what exactly Industry 4.0 is. This is the case, because nobody exactly knows how it will look like. Just like our respondents, people cannot predict the future but can only guess on basis of experience and knowledge. Therefore, the subject of Industry 4.0 will remain uncertain. Luckily, with the framework I created, it will at least be possible to sort literature into different categories. This will allow us to keep an overview which stream of Industry 4.0 seems to develop stronger, which weaker and which new streams might occur in the future, that cannot be predicted now. Also, things are less clear and more double-sided than expected earlier. From an academical perspective this paper can therefore deliver a lot of value. On the basis of my definition and framework it will be possible to compare different articles and to focus future research on what is important – namely giving practical advice to companies. Lots of time was spend on finding the right definition of Industry 4.0. Now it is time to do the next step and focus on more details and practical solutions. With the findings of this research companies are enabled to finally start preparing their production, employees and structure for the future. By combining the research power of ten different European countries, we learned that Industry 4.0 is not only led by engineers, who create the new technology, but also by users of it like individual employees. Companies can understand this paper as a wake-up call, to start getting proactive to Industry 4.0 in a structured and goal-oriented way. From my research companies can learn that many things Industry 4.0 has an influence on were not considered yet. After this research the whole extent of Industry 4.0 is finally clarified and can/should be used in practice.

5.2 Line Management in Industry 4.0

Also, for line managers this research delivered important insights. Most importantly, it was found that Industry 4.0 indeed will have a crucial influence on the role of line managers. Still, the opinions on what this will look like differ per expert and are highly dependent on the experts' knowledge domain within HR. At the beginning of this research it was assumed that due to technological development line managers will either be supported or substituted. In this research it was found that it is more likely that line managers will find support in the new technological developments. This is, because HR will get more strategic in the future, what leaves more practical and administrative tasks to line managers. As foreseen, the new technologies will be part of the daily work of line managers. Still,

some adjustments must be made regarding certain expectations. Even though predicted differently, face-to-face communication will still be the main way to communicate. The respondents in the interviews do not think that new communication technologies will ever be able to reach the level of communication-richness personal contact offers. Next to this, there was no proof that the level of leadership will decrease. Even though the type of leadership might shift towards more shared leadership, we cannot expect leaderless organizations or the like to be happening in Industry 4.0. Connected to this was the assumption that decentralization of decision making will occur. As can be seen from my definition of the different roles of line managers, decision making will stay one of their major tasks, meaning that this prediction was false. All in all, we can therefore say that the role of line managers is crucial and will, at least in the experts' opinion, not be substituted by technologies of Industry 4.0. Looking at all of this, something else was found, namely that the definitions, examples and ideas of the experts on Industry 4.0 are not new. Examples of this are the flattening of organizations, the increase in communication and data usage, less supervision and more charismatic leadership. Everybody who just is just a bit based in research of HRM can see that all findings of this research are nothing new and are really limited to already known theories. All the effects the experts identified are already taking place since a long time, such as the increase in shared leadership and self-managing teams (Barker, 1993). So, I can conclude that many of the given examples are actually not related to Industry 4.0 at all. We can see from this that HR experts nowadays are way too much focused on the present and current situation instead of thinking about the future. To do so out-of-the-box thinking is needed next to inspiration and innovative ideas. Looking at what was found from the interviews we can see that HR researchers are not talking about radical changes but instead focus on technical developments that are already taking place since years. Still, some of the named changes such as the direct feedback of machines or the possibility to select certain information of workers is a unique trait of this industrial revolution and is considered a current/new change. Here we see a good start for thinking about possible changes for line managers in Industry 4.0. Anyways, we can also say that many of the researchers are conscious of this problem. Especially from the HR researchers with a more technological research focus we heard a lot of critic on the positioning of HR towards the future.

This leads us to the implication this research leads to. The most obvious one is for HR researchers to start thinking about what HR in the future really could look like. This paper can be seen as a call to stop focussing on the old and known technologies and to start thinking about which new technologies might arise and how that will affect line managers and other workers. This research therefore allows future groundwork to dig deeper into this question. Further, as mentioned at the beginning of this paper, not much information about the role of line managers in Industry 4.0 was available. My research gives a list of roles that line managers will perform in the future. Upcoming research can use the findings of this paper to go into more depth in the single roles they perform. I also suggest to conduct a research that clearly investigates the question how Industry 4.0 will substitute and/or support line managers in detail. Also, this research can be used as a manual for line managers to get clear about their tasks and their responsibilities. Of course, there is also a practical advantage, namely that companies, now finally knowing what Industry 4.0 is, can train their line managers in an appropriate way. Companies can now see what skills they must educate their line managers in too achieve the best fit between organizational output and the well being of employees in the future. All in all, this paper identified that an increase in training is needed as the role of line managers is about to get more complex and they so need to acquire more (varying) competencies. On the basis that I created, future groundwork but also companies themselves can come up with ideas on how to bring this knowledge to practice. It is now possible to develop training programs in which line managers get prepared for Industry 4.0, and in which they can develop the skills, described in this paper.

5.3 Limitations

Even though this research got conducted with the best care and attention, some limitations occur. The biggest one probably is the focus of this research on solely European countries. This allowed me to focus and to gather more specific data. Anyways, it also led to the fact that other major players on the world market got ignored. Even though the EU and its member states are playing an important role, also in developing technology and conducting research concerning Industry 4.0, other countries from, for example Asia or North-America, are not considered. It would be interesting in how much the definition/components of Industry 4.0 and the role of line managers differ in comparison with European standards. It is therefore important to conduct similar research like this for other geographical areas, as Industry 4.0 is a world-wide development and not only a local one. Same is valid for the expert interviews which were only conducted with members of the Dutch HRM Network. It must be expected that other HR experts with a different cultural- and knowledge-background can contribute other information and perspectives to this research, to expand it towards a more holistic, globally valid study. A last limitation I want to mention is caused by the fast-changing nature of Industry 4.0. Many of the components and effects identified in this paper could already be out-dated in a few years. This means that my study is just a snap-shot of the current situation. As mentioned before, Industry 4.0 seems to be a topic of high uncertainty, which is why I suggest to conduct this study again in some time to see further development and progress. Therefore, it could be necessary to adjust the framework as new components might arise and others might gain or lose significance, and so eventually influence the role of line managers.

6. CONCLUSION

Industry 4.0 still seems to be a topic that needs lots of discussion – even after this research. So, what can we learn from it then? We can see that Industry 4.0 is much more then most people would expect it to be; that it is more than just complicated, far-away technology, but that it will influence all of our working and private lives as well. This is also valid for line managers who seem to be notably affected by the changes. Their role in the future will be supported and encouraged by the new technology, making many of the simpler tasks easier. But it will also complicate their role, adding more managerial tasks and so require more skills and knowledge than ever before. For sure Industry 4.0 is a topic that goes hand in hand with much uncertainty and this means that it will always be a matter to talk about. Still, this paper gave a good overview on what can be expected and what is currently discussed on a European level. How this relates to the role of line managers did not find a lot of attention till now. I hope to make the first step with this paper to motivate more researchers to investigate this subject and the important role line managers will play. By doing so the necessary training and acquire of competencies can be put in place. A few years ago, nobody would have expected this new organizational development to happen – "but with the swift pace of change and disruption to business and society, the time to join in is now" (Coleman, 2016).

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Appendix 1 - Literature Matrix

Number	Country	Article	Definition of Industry 4.0	Sources of Infomation/Definitions	Components of I4.0
1	Austria	Association Industry 4.0 Austria (n.d.), *What is Industry 4.0?.* Retrieved on 16.05.2018, from: http://plattformindustrie40.at/was-ist-industrie-4-0/?lang=en	Industry 4.0 is defined as the digitalization and integration of the entire value chain and follows the mechanization, electrification and automation as the fourth industrial revolution. the change is taking place at all stages of the production process (value chain). Industry 4.0 refers to both upstream and downstream integration such as suppliers or logistics company as well as internal corporate processes such as procurement, production, sales and maintenance. Therefore, Industry 4.0 leads to higher productivity and flexibility, more innovation and resource preservation.	Association Industry 4.0 Austria - the Platform for Smart Production	- Smart factories - Improving the organization and control of production processes - Deeper integration of upstream and downstream activities (internal and external) - Increasingly multidisciplinary and overall acceleration of research and development
2	Austria	Lassnig et al. (2016) *Industrie 4.0 in Österreich. Kenntnisstand und Einstellung zur digitalen Transformation durch Industrie 4.0 und neue Geschäftsmodelle in österreichischer Unternehmen In: Report from the Bundesministerium für Verkehr, Innovation and Technologie.* Retrieved on the 12.05.2018, from: http://plattformindustrie40.at/wp-content/uploads/2016/03/I40-Transform_D2_Industrie40-in-%C3%96sterreich.pdf	Industry 4.0 is not a revolution in the perception of Austrian companies, but an Evolution - but with far-reaching effects on competitiveness. The assessment as pure evolution, however, is also a greatly shortened view and carries the risk, not in the (future) innovation leaders in digitization.	Federal Ministry of Transport, Innovation and Technology	- transformations are advances in sensor technology and in information and communication technology 1) Cyber-physical systems (CPS) 2) Internet of Things , Industrial Internet
3	Belgium	Sirris & Agoria (2018), *Made Different - Enabling Factories of the Future.* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en		Association 'Made Different Belgium'	7 transformations: 1. World Class Manaufacturing Technologies 2. End-to-end Engineering 3. Digital Factory 4. Human Centered Production 5. Production Network 6. Eco Production 7. Smart Production Systems
4	Belgium	Pagegroup (10.01.2018), *Industry 4.0 will make Belgium an attractive destination for engineers* Retrieved on 16.05.2018, from: https://www.michaelpage.be/advice/market-updates/industry-40-will-make-belgium-attractive-destination-engineers	Smart Factory = equipped with self-learning machines and robotics, all of which requires different ways of working	Consulting company with relationship to European Union	IoT, Manufacturing execution systems (MES), Self-learning machines
5	Belgium	Sirris & Agoria (24.02.2016), *What is Factory of the Future 4.0?* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en/what-factory-future-40		Association 'Made Different Belgium'	-digitised production processes 2 main areas 1. Technological Innovation 2. Social Innovation
6	Belgium	Sirris & Agoria (24.02.2016), *About Made Different* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en/about-made-different	The possibility to stop jobs from moving abroad and to produce mass customized products on a social- and environmental friendly basis. Smart factories are having the potential of outperforming new competitors by entering new markets with new technologies , while at the same time meeting new social standards	Association 'Made Different Belgium'	- mass customization - environmently friendly technologies
7	Belgium	Sirris (n.d.), *IBN Digitising Manufacturing* Retrieved on 20.05.2018, from: https://www.sirris.be/nl/ibn-digitising-manufacturing	The digitalization of production processes, and introduction of new competition based new technologies	Member of the Belgian Research Platfrom	6 Main topics 1. managing increased complexity 2. enabling fast response 3. supporting operators in their tasks 4. enabling first time right production 5. making the shop floor transparent 6. creating a manufacturing network
8	Belgium	Sirris (n.d.), *Digital Journes Tracker* Retrieved on 20.05.2018, from: https://www.sirris.be/nl/digitaljourneytracker	Digitalization of 1. Physical products 2. Digital Products 3. Services	Member of the Belgian Research Platfrom	Digitalization of 1. Physical products 2. Digital Products 3. Services

9	Belgium	EWI Vlaanderen (02/2017), *Startnota - Transitie - 'De sprong maken naar industrie 4.0'* Retrieved on 20.05.2018, from: https://ewi-vlaanderen.be/sites/default/files/bestanden/startnota_sprong_maken.pdf	Industry 4.0 is a nexus for new technologies and concepts within the economy. It especially includes the digitalization of the industry which is taking place right now	Paper of Research Institution	- Factories of the future - transition from product to service companies - mass customization - hypercompetition - increased competition for rare resources & workforce
10	Belgium	Belgiian Government (06/2017), Digital Belgium Retrieved on 20.05.2018, from: http://digitalbelgium.be/wp-content/uploads/2017/07/compressed_Brochure_DB_FINAL.pdf		Governmental research association	- Fast internet access - Better informed customers with possibility to easily switch - New Digitial Job Boom - Open Data & Data Management - Safe & Privacy friendly online environment - Cyber Security 5 "priorities" - Digital Economy - Digital Infrastructure - Digital Skills and Jobs - Digital Government - Digital Confidence and Digital Security
11	Belgium	Walloon Government (n.d.), Digital Wallonia - We are transforming Wallonia Retrieved on 20.05.2018, from: https://www.digitalwallonia.be/en		EU financed research based on the 'Made Different' association	5 major topics of strategy - Digital Sector - Digital Economy - Skills&Jobs - Open public Services - Smart&Connected territory
12	Belgium	Deliége (16/01/2017), *Made Different Digital Wallonia. Moving towards the industry of the future* Retrieved on 21.05.2018, from: https://www.digitalwallonia.be/en/posts/made-different-digital-wallonia	Smart processs creating smart products within smart business models, influencing the professions of the future and humans at the heart of the company, challenging and depending on business networks	EU financed research based on the 'Made Different' association	- Internet of Things - Artificial intelligence - Big Data - The Cloud - Product personalisation
13	Belgium	Butera (04/05/2018), *Digital Wallonia @ DES 2018* Retrieved on 21.05.2018, from: https://www.digitalwallonia.be/en/posts/digital-wallonia-des-2018		EU financed research based on the 'Made Different' association	- Cloud Computing - Security - IoT - ERP/CRM - Digital Marketing - Big Data & Analytics - Block Chain - Artifical Intelligence
14	Denmark	Manufacturing Academy of Denmark (n.d.), *MADE SPIR* Retrieved on 16.05.2018, from: http://en.made.dk/spir/	Fast developped customer specific mass production	Own source	high speed product development, modular production platforms, 3d print and new production processes, model based supply chain development, digitalisation of supply chains, lifelong product customization, "new" manufacturing paradigm, hyper flexible automation, sensors and quality control.
15	Denmark	Danish Institute of Industry 4.0 (n.d.), Industry 4.0 Retrieved on 03.05.2018, from: https://www.dii4.dk	An increasingly digitisation and interconnection of value chains and business models. Industry 4.0 creates Smart Factories and is based upon cyber-physical systems allowing the manufacturer to control the entire production from one platform.	Website	3 fundamental enablers: costs, technological sophistication and the internet. more specific:autonomous robots, simulation, additive manufacturing, augmented reality, horizontal and vertical integration, internet of things, cyber security, the cloud, big data and analytics, computational power, AI and machine learning, mobile devices, scanning technology, camera technology, software and algorithms.
16	Denmark	Rajkumar, Madsen & Skov (2017), *Industry 4.0 in Danish Industry* Retrieved on 22-05.2018, from: http://www.efnms.eu/wp-content/uploads/2017/06/Stentoft-Rajkumar-Madsen-2017-Industry_4_0_in_Danish_Industry.pdf	a construct of materials and manufacturing smart technologies, connectivity smart technologies and data handling and big data	Own source	materilals and manufacturing smart technologies consists of: 3d printing, 3d scanning, robotics, iBin, advanced materials and augmented reality and simulation. connectivity smart technologies consists of: mobile internet, advanced sensors, remote control and enterprise resource planning. data handling and big data consists of: simulation, big data digital documentation, automatic analysis and visualization of data, cloud computing and the internet of things.

17	Germany	Federal Ministry for Economic Affairs and Energy (n.d.), *What is Industrie 4.0?* Retrieved on 12.05.2018, from: https://www.plattform-i40.de/I40/Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html;jsessionid=F782F8ED43F6B87E00A7BE0D0268DC6E	Industrie 4.0 combines production methods with state-of-the-art information and communication technology. The driving force behind this development is the rapidly increasing digitisation of the economy and society. It is changing the future of manufacturing and work in Germany: In the tradition of the steam engine, the production line, electronics and IT, smart factories are now determining the fourth industrial revolution.	German governmental site for Industry 4.0	- smart factories --> digitalised industrial process, new security concepts, norms and standards: a common language for Industry 4.0 technologies, legal framework: between data protection and supporting innovation, research and innovation: exchanging knowledge for the products of tommorrow
18	Germany	Adamczyk et al. (2016), *Industrie 4.0 security in vocational and advanced training. New issues for business organisation and expertise* . Retrieved on the 13.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/i40-security-vocational-training.html		"Security of networked systems" Platform Industrie 4.0 working group.	- mastering security know-how in accordance with target group requirements and roles - security/trust
19	Germany	Federal Ministry of Economic Affairs and Energy (n.d.) *German industry launches standardization initiative for Industrie 4.0:Standardization Council I4.0" founded by Federal Ministry of Economic Affairs and Energy.* Retrieved on the 13.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/blog-standardization-council-en.pdf?__blob=publicationFile&v=4	The comprehensive networking of technical systems and processes taking place with the digitalization of industry and infrastructure is leading to an increasing merger of the physical and virtual worlds	Federal ministry of Economic Affairs and Energy	1) Internet of Things and Services 2) Standardization
20	Germany	Federal Ministry for Economic Affairs and Energy (06/2017), *Industrie 4.0 Plug-and-Produce for Adaptable Factories: Example Use Case Definition, Models, and Implementation* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/Industrie-40-%20Plug-and-Produce.pdf?__blob=publicationFile&v=7			order controlled production, adaptable factories, self-organizing adaptive logistics, value based services, transparency and adaptibility ofdeliver products, operator support in production, smart product development for smart production, innovative product development, circular economy
21	Germany	Federal Ministry for Economic Affairs and Energy (n.d.), *Work 4.0 - How will digitised industrial processes affect work? by platform Industrie 4.0* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/areas-of-action-work.html	The fundamental change will occur in the way these products and services are manufactured and delivered in the future. In the future, communication in factories will often be seamless and wireless, enabling employees to interact more efficiently with intelligent production equipment. This development will open up opportunities for work to be organised differently, for example with workplaces that are designed to be health-friendly, and more flexible and family-friendly working arrangements.	Federal ministry of Economic Affairs and Energy	
22	Germany	Federal Ministry for Economic Affairs and Energy (06/2017), *Relationships between I4.0 Components – Composite Components and Smart Production* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/hm-2018-relationship.pdf?__blob=publicationFile&v=3	machine to machine cooperation(instead of human to human-human to machine)	own source	
23	Hungary	MTA SZTAKI (n.d.), *The Industry 4.0 National Technological Platform Association (I4.0 NTP)* Retrieved on 16.05.2018, from: https://www.i40platform.hu/en/about_us	integration of the physical and virtual worlds, and represents a new level of organising and controlling the entire value chain across product lifecycles. This cycle focusses on increasingly personalised customer wishes and extends from the concept to the order, development, production, and shipping of a product to the end customer and ultimately to its recycling, including all associated services.	https://www.i40platform.hu/sites/default/files/2017-08/Industrie%204.0_Definition_0.pdf	horizontal integration, vertical integration, smart products, humans as drivers of added value.
24	Hungary	European Commision (12/2017), Digital Transformation MonitorHungary:"IPAR 4.0 National Technology Platform" Retrieved on 16.05.2018, from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_IPAR_HU_v4.pdf			1. StrategicPlanning 2. Employment,Education and Training 3. ProductionandLogistics 4. ICTTechnologies 5. Industry4.0Cyber-PhysicalPilot Systems 6. InnovationandBusinessModel 7. LegalFramework

25	Italy	Ministero dell'Economia e delle Finanze (n.d.), *Italy's national plan Impresa 4.0 - Resutls from 2017-Actions for 2018* Retrieved on 16.05.2018, from: http://www.sviluppoeconomico.gov.it/images/stories/documenti/impresa_40_risultati_2017_azioni%202018_rev_eng.pdf		Own source: Ministry of Finance, economy of Italy	Impresa 4.0 objectives 2017-2020: innovative investments, skills, enabling infrastructures, other support measures
26	Lithuania	Silkroad 4.0 (2017), *Lithuania* Retrieved on 16.05.2018, from: https://www.silkroad40.com/lithuania/	repatriation of production from east asian countries to Europe and the establishment of a digital innovation hub	Own source	Big Data, Cloud computing, IoT, Robotics, Autonomous systems
27	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (06.11.2017), *Luxembourg gets serious about Industry 4.0* Retrieved on 12.05.2018, from: https://www.luxinnovation.lu/news/luxembourg-gets-serious-about-industry-4-0/	Industry 4.0 is considered one of the key technologies necessary to secure the future competitiveness of industrial companies in the western world. If you were to ask what the ultimate vision of Industry 4.0 is, I would say that it would be to produce high-added value products at the cost of the mass production	National Agency for Innovation and Research, and the Ministry of the Economy	Mass customization
28	Luxembourg	Luxembourg Institute of Science & Technology - LIST (2015), *Smart Manufacturing - Carrying out the industrial revolution.* Retrieved on 10.052018, from: https://www.list.lu/en/cooperations/innovation-programmes/smart-manufacturing/	Smart manufacturing = the digital organisation and management of processes and data associated with the value chain in the manufacturing sector	Research Institution serving the national and European economy and society	Role of Business in Smart manufacturing = remain innovative in an increasingly competitive economic environment, increase their productivity while reducing the costs, provide highly customized products, and have ever shorter time-to-market and delivery times. In order to develop new products and associated services, manufacturing companies need to understand new business models, reduce their impact on the environment and natural resources, integrate digital technologies to enhance yield and manufacturing processes, and, of course, comply with increasingly strict environmental regulations
29	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (n.d.), *Industry 4.0* Retrieved on 10.05.2018, from: https://www.fedil.lu/en/topics/industry-4-0/		National Agency for Innovation and Research, and the Ministry of the Economy	1. Big Data 2. Internet of Things (IoT) 3. Cloud
30	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (n.d.), *Visit of the smartfactory in Kaiserslautern* Retrieved on 10.05.2018, from: https://www.fedil.lu/en/events/visit-of-the-smartfactory-in-kaiserslautern/	No clear definition given but, description of economy of the 21st century is characterized as: "global competition, ever shorter innovation and product life cycles, as well as a growing demand for individualized products"	National Agency for Innovation and Research, and the Ministry of the Economy	Less components than more effects of the new industry: - global competition - indiivudalized products - shorter product life cycles Components 1. Modern communication technology 2. Wireless Sensors 3. Semantic product memories 4. mobile interaction 5. Internet of Things 6. Factory of Things
31	Luxembourg	Larosse (10.10.2017), Analysis of national initiatives on digitising european industry - *Luxembourg: Digital4Industry.* Retrieved on 12.05.2018, from: https://ec.europa.eu/futurium/en/system/files/ged/lu_country_analysis.pdf		Country analysis on behalve of European Union	
32	Luxembourg	European Comission (2016) -*Digital Scoreboard 2016 and other information relevant for decisions about Digital Innovation Hubs - Luxembourg* Retrieved on 12.05.2018, from: https://ec.europa.eu/futurium/en/system/files/ged/luxembourg_211117.pdf		Information document from European Union based on: https://cohesiondata.ec.europa.eu/countries/LU and https://ec.europa.eu/futurium/en/content/report-wg1-digital-innovation-hubs-mainstreaming-digital-innovation-across-all-sectors-final	Not real components but areas Industry 4.0 has an impact on: 1. Connectivity 2. Human Capital 3. Use of Internet 4. Integration of Digital Technology 5. Digital Public Services

33	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (12.05.2016), *Industry 4.0 Platform Luxembourg*			
34	Portugal	Republica Portugesa & Cotec Portugal (n.d.) *i4.0- Industria 4.0 - About.* Retrieved on 10.05.2018, from: https://www.industria4-0.cotec.pt/en/about/		Website of the Protugese Government and other govenrmental institutions	
35	Portugal	European Commission (05/2017), *Digital Transformation Monitor - Country:Portugal"Industria 4.0".* Retrieved on 10.05.2018, from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Ind%C3%BAstria%204.pdf	Industria 4.0 = a strategy to develop industry in the digital area and to identify the real needs of the Portugese industry	Website of the Protugese Government and other govenrmental institutions	3 axes: Digitalisation Innovation Training 6 pillars: human qualification, technological cooperation, start-up i4.0, financing and investment incentives, internationalisation and standards and regulation.
36	Sweden	Government Offices of Sweden - Ministry of Enterprise and Innovation (2016), *Smart Industry - a strategy for new industrialisation for Sweden.* Retrieved on 10.05.2018, from: http://www.government.se/498615/contentassets/3be3b6421c034b038dae4a7ad75f2f54/nist_statsformat_160420_eng_webb.pdf	Smart Industry is defined as innovative and sustainable industrial production that is digitally connected, flexible, resource-efficient, environmentally friendly and provides the conditions for an attractive workplace	Swedish government site for Industry 4.0	4 Focus areas of Smart Industry: Industry 4.0 – Exploit the potential of digitalisation • Sustainable production – Improve the industrial sector's capacity for sustainable and resource-efficient production • Industrial skills boost – Ensure the supply of skills to the industrial sector • Test bed Sweden – Create attractive innovation environments - sustainable / environmental friendly production - digitally connection - workplace improvement technologies
37	Sweden	Business Sweden - The Swedish Trade & Investment Council (n.d.), *Smart Industry - The big rethink: Manufacturing in a digital world* Retrieved on 13.05.2018, from: https://www.business-sweden.se/en/Invest/industries/Manufacturing/smart-industry/	Smart Industry = a strategic initiative launched by the Swedish government to strengthen Sweden's capacity for change and competitiveness in a shifting landscape for manufacturing and production. The emerging, data-driven industrial age promises to unlock vast opportunities for innovation. But the transition also presents some real threats	Definition retrieved from: http://www.government.se/498615/contentassets/3be3b6421c034b038dae4a7ad75f2f54/nist_statsformat_160420_eng_webb.pdf	1. Industry 4.0 - Companies in the Swedish industrial sector are to be leaders of the digital transformation and in exploiting the potential of digitalisation 2. Sustainable production - Increased resource efficiency, environmental considerations and a more sustainable production are to contribute to the industrial sector's value creation, job creation and competitiveness. 3. Industrial skills boost - The system for supplying skills is to meet the industrial sector's needs and promote its long-term development 4. Test bed Sweden - Sweden is to lead research in areas that contribute to strengthening the industrial production of goods and services in Sweden
38	Sweden	Telefonaktiebolaget L. M. Ericsson (n.d.), *Welcome to the smart factory* Retrieved on 13.05.2018, from: https://www.ericsson.com/en/cases/2017/smartfactory	Industry 4.0 = merging operational, information and communication technologies with cyber-physical systems, enabled by advanced wireless communication and Industrial Internet of things (IoT) services. Manufacturing companies are betting on 5G to deliver ultra low latency, high bandwith and reliable communication to realize the smart factory.	Company Website (company works in close clearance with European government (see following link)) http://s3platform.jrc.ec.europa.eu/documents/20182/221302/Industry+4.0+draft+agenda+Budapest_in+Save+the+date.pdf/25943edf-f62b-4806-96c6-f20d0c418f30	CPS, wireless communication, IoT,

Number	Country	Article	Implications for line-managers	Important remarks
1	Austria	Association Industry 4.0 Austria (n.d.), *What is Industry 4.0?*. Retrieved on 16.05.2018, from: http://plattformindustrie40.at/was-ist-industrie-4-0/?lang=en		
2	Austria	Lassnig et al. (2016) *Industrie 4.0 in Österreich. Kenntnisstand und Einstellung zur digitalen Transformation durch Industrie 4.0 und neue Geschäftsmodelle in österreichischer Unternehmen In: Report from the Bundesministerium für Verkehr, Innovation and Technologie.* Retrieved on the 12.05.2018, from: http://plattformindustrie40.at/wp-content/uploads/2016/03/I40-Transform_D2_Industrie40-in-%C3%96sterreich.pdf	- work together with other line-mangers as interdisciplinary skills of workers are nessacary	- fear of workers of change should also be taken into account
3	Belgium	Sirris & Agoria (2018), *Made Different - Enabling Factories of the Future.* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en		
4	Belgium	Pagegroup (10.01.2018), *Industry 4.0 will make Belgium an attractive destination for engineers* Retrieved on 16.05.2018, from: https://www.michaelpage.be/advice/market-updates/industry-40-will-make-belgium-attractive-destination-engineers	Importance of knowledge training Change Management Skills needed	
5	Belgium	Sirris & Agoria (24.02.2016), *What is Factory of the Future 4.0?* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en/what-factory-future-40		Point out the labour/emlpoyee/human based effects of the new Industry (Social view) Factories of the Future 4.0 = forward-looking manufacturers who systematically take up the challenges of the fourth industrial revolution. They supply products with high value added and are flexible enough to respond to swiftly changing market demand. This also enables them to continue playing a major role in a dynamic worldwide manufacturing network.
6	Belgium	Sirris & Agoria (24.02.2016), *About Made Different* Retrieved on 10.05.2018, from: http://www.madedifferent.be/en/about-made-different	Involvement of employees in new policy making	Challenges for technology in the future: - lower CO2 emissions - state-of-the-art production facilities - foster participation, creativity and autonomy of its staff - develop products with high added value - respond quickly to changing market demand
7	Belgium	Sirris (n.d.), *IBN Digitising Manufacturing* Retrieved on 20.05.2018, from: https://www.sirris.be/nl/ibn-digitising-manufacturing		Focuses on the competitive advantage a company gains through using Industry 4.0 - increased responsiveness - customer roiented services - introduction of new future oriented services
8	Belgium	Sirris (n.d.), *Digital Journes Tracker* Retrieved on 20.05.2018, from: https://www.sirris.be/nl/digitaljourneytracker		
9	Belgium	EWI Vlaanderen (02/2017), *Startnota - Transitie - 'De sprong maken naar industrie 4.0'* Retrieved on 20.05.2018, from: https://ewi-vlaanderen.be/sites/default/files/bestanden/startnota_sprong_maken.pdf		This is a really good paper, concerning not only Flanderen but whole Europe and gies a good overview over different research association within the EU
10	Belgium	Belgiian Government (06/2017), Digital Belgium Retrieved on 20.05.2018, from: http://digitalbelgium.be/wp-content/uploads/2017/07/compressed_Brochure_DB_FINAL.pdf		Does not deliver much on the theoretical framework of Industry 4.0, but instead focuses on future problems/interest areas
11	Belgium	Walloon Government (n.d.), Digital Wallonia - We are transforming Wallonia Retrieved on 20.05.2018, from: https://www.digitalwallonia.be/en		More action based (already have a strategy) than giving a clear overview over terms and definitions. --> Thinking a step to far
12	Belgium	Deliége (16/01/2017), *Made Different Digital Wallonia. Moving towards the industry of the future* Retrieved on 21.05.2018, from: https://www.digitalwallonia.be/en/posts/made-different-digital-wallonia		Industry 4.0 is the opportunity to re-industrialise our region & boost the Walloon digital economy

13	Belgium	Butera (04/05/2018), *Digital Wallonia @ DES 2018* Retrieved on 21.05.2018, from: https://www.digitalwallonia.be/en/posts/digital-wallonia-des-2018		
14	Denmark	Manufacturing Academy of Denmark (n.d.), *MADE SPIR* Retrieved on 16.05.2018, from: http://en.made.dk/spir/	usage of standardized production equipment that must be able to produce varying products.	The Danish want to achieve fast paced, customized production and development of products. Their strategy lies a high emphasis on making product/design components, production and the entire supplychain modular. think IT-empowered lego.
15	Denmark	Danish Institute of Industry 4.0 (n.d.), Industry 4.0 Retrieved on 03.05.2018, from: https://www.dii4.dk		I4.0 distinguishes itself in the sense that there is an increased pace of change, increased complexity, less replacement(!) of core production equipment and more disruption. furthermore adoption of 4.0 may be hard due to lack of commitment from senior management.
16	Denmark	Rajkumar, Madsen & Skov (2017), *Industry 4.0 in Danish Industry* Retrieved on 22-05.2018, from: http://www.efnms.eu/wp-content/uploads/2017/06/Stentoft-Rajkumar-Madsen-2017-Industry_4_0_in_Danish_Industry.pdf		
17	Germany	Federal Ministry for Economic Affairs and Energy (n.d.), *What is Industrie 4.0?* Retrieved on 12.05.2018, from: https://www.plattform-i40.de/I40/Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html;jsessionid=F782F8ED43F6B87E00A7BE0D0268DC6E		There is a Working group on work, education and training The transition to a networked industry will only succeed in Germany if the relevant actors are involved in the process of change from the outset. Plattform Industrie 4.0 follows this principle and brings together a circle of people who will take up these issues in a dedicated working group. The working group on work, education and training has defined three closely interrelated fields for its endeavours: In networked information and production spaces, human-machine interfaces and cooperation must be designed to serve the interests of the people involved and the innovative capacity of enterprises. The organisational frameworks for coalescing value networks must be designed to facilitate working and learning within the processes. Training and qualification programmes in hybrid fields must be designed to accommodate operational skills development, processoriented learning and new forms of learning.
18	Germany	Adamczyk et al. (2016), *Industrie 4.0 security in vocational and advanced training. New issues for business organisation and expertise .* Retrieved on the 13.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/i40-security-vocational-training.html		
19	Germany	Federal Ministry of Economic Affairs and Energy (n.d.) *German industry launches standardization initiative for Industrie 4.0:Standardization Council I4.0" founded by Federal Ministry of Economic Affairs and Energy.* Retrieved on the 13.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/blog-standardization-council-en.pdf?__blob=publicationFile&v=4	- convergence of office-floor and shop-floor communication through common standards	
20	Germany	Federal Ministry for Economic Affairs and Energy (06/2017), *Industrie 4.0 Plug-and-Produce for Adaptable Factories: Example Use Case Definition, Models, and Implementation* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/Industrie-40-%20Plug-and-Produce.pdf?__blob=publicationFile&v=7		
21	Germany	Federal Ministry for Economic Affairs and Energy (n.d.), *Work 4.0 - How will digitised industrial processes affect work? by platform Industrie 4.0* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/areas-of-action-work.html	- Software and sensors monitor production processes. This raises concerns that workers will also become the subject of this supervision and control in the future.	
22	Germany	Federal Ministry for Economic Affairs and Energy (06/2017), *Relationships between I4.0 Components – Composite Components and Smart Production* Retrieved on 16.05.2018, from: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/hm-2018-relationship.pdf?__blob=publicationFile&v=3		despite the title the article refers mainly to I4.0 from an IM perspective, meaning the components can be production managers and units in a factory that communicate with eachother. the article aims at creating a language for industry 4.0 allowing machines to communicate with eachother.
23	Hungary	MTA SZTAKI (n.d.), *The Industry 4.0 National Technological Platform Association (I4.0 NTP)* Retrieved on 16.05.2018, from: https://www.i40platform.hu/en/about_us		follows german example.
24	Hungary	European Commision (12/2017), Digital Transformation MonitorHungary:"IPAR 4.0 National Technology Platform" Retrieved on 16.05.2018, from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_IPAR_HU_v4.pdf		idem + mixture of both state support and new private financing. furthermore the initiative is only 1.5 years old, so not very developped as of yet. hungary is currently lacking in digital infrastructure, both on the technical side as on the human side.

25	Italy	Ministero dell'Economia e delle Finanze (n.d.), *Italy's national plan Impresa 4.0 - Resutls from 2017-Actions for 2018* Retrieved on 16.05.2018, from: http://www.sviluppoeconomico.gov.it/images/stories/documenti/impresa_40_risultati_2017_azioni%202018_rev_eng.pdf		Innovation is a great opportunity. Thanks to the National Industry 4.0 Plan Italian companies can now choose from a wide range of measures to help them win the challenge set by the digital revolution. The plan is an oppotunity: for a smart and innovative industry, for an even more competitive Made in Italy, to be future ready
26	Lithuania	Silkroad 4.0 (2017), *Lithuania* Retrieved on 16.05.2018, from: https://www.silkroad40.com/lithuania/		
27	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (06.11.2017), *Luxembourg gets serious about Industry 4.0* Retrieved on 12.05.2018, from: https://www.luxinnovation.lu/news/luxembourg-gets-serious-about-industry-4-0/		Focus on leanring machines and Data management
28	Luxembourg	Luxembourg Institute of Science & Technology - LIST (2015), *Smart Manufacturing - Carrying out the industrial revolution.* Retrieved on 10.052018, from: https://www.list.lu/en/cooperations/innovation-programmes/smart-manufacturing/		In Luxembourg the research is mainyl coordinated by the UEL (the Luxembourg Employers' Association)
29	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (n.d.), *Industry 4.0* Retrieved on 10.05.2018, from: https://www.fedil.lu/en/topics/industry-4-0/	Should foster entrepreneurial behaviour by motivating independent and creative working behaviour	Focus on SMEs and the imporvement of productivity for them
30	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (n.d.), *Visit of the smartfactory in Kaiserslautern* Retrieved on 10.05.2018, from: https://www.fedil.lu/en/events/visit-of-the-smartfactory-in-kaiserslautern/		Invention of smart technology first in consumer- then in industry-sector
31	Luxembourg	Larosse (10.10.2017), Analysis of national initiatives on digitising european industry - *Luxembourg: Digital4Industry.* Retrieved on 12.05.2018, from: https://ec.europa.eu/futurium/en/system/files/ged/lu_country_analysis.pdf	Skill development	This document does not deliver a clear defintion of the term but shows that this initiative is busy with conferences and meeting that try to discuss the topic Sees industry 4.0 more as a political than a technical change/problem
32	Luxembourg	European Comission (2016) *-Digital Scoreboard 2016 and other information relevant for decisions about Digital Innovation Hubs - Luxembourg* Retrieved on 12.05.2018, from: https://ec.europa.eu/futurium/en/system/files/ged/luxembourg_211117.pdf		Luxembourg focuses on Human capital
33	Luxembourg	Luxinnovation Union des Entreprises Luxembourgeoises (UEL) (12.05.2016), *Industry 4.0 Platform Luxembourg*		5 problems coming through Industry 4.0: 1. Unclear economic benefits, excessive investments; 2. Interoperability and lack of technical standards, protocols, regulations and certifications; 3. Cyber security and protection of data and intellectual property; 4. Availability of Industry 4.0 products and solutions, need for an end-to-end hardware and software supply; 5. Availability of skilled workers that can design and operate Industry 4.0 equipment. This approach allows to sensitise and inform about the most important issues by adopting a large
34	Portugal	Republica Portugesa & Cotec Portugal (n.d.) *i4.0- Industria 4.0 - About.* Retrieved on 10.05.2018, from: https://www.industria4-0.cotec.pt/en/about/		Industria 4.0 = paradigm shift in industry – in fact, across the economy. A Fourth Industrial Revolution is under way and will bring in digital technologies across all industries. Definition remains weak and seems to more advertising the own industry instead of clarifying the term
35	Portugal	European Commission (05/2017), *Digital Transformation Monitor - Country:Portugal"Industria 4.0".* Retrieved on 10.05.2018, from: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Ind%C3%BAstria%204.pdf	Need for digital and skills transformation	Industria 4.0 is focused on the needs of SMEs only
36	Sweden	Government Offices of Sweden - Ministry of Enterprise and Innovation (2016), *Smart Industry - a strategy for new industrialisation for Sweden.* Retrieved on 10.05.2018, from: http://www.government.se/498615/contentassets/3be3b6421c034b038dae4a7ad75f2f54/nist_statsformat_160420_eng_webb.pdf		3 changes in industrialization 1. GIobalisation 2. Digitalisation 3. Green, resource-efficient economy Focus on sustainability and environmental friendliness --> can be found back in Belgium but NOT in Germany
37	Sweden	Business Sweden - The Swedish Trade & Investment Council (n.d.), *Smart Industry - The big rethink: Manufacturing in a digital world* Retrieved on 13.05.2018, from: https://www.business-sweden.se/en/Invest/industries/Manufacturing/smart-industry/		Industry 4.0 as a subpart of Smart Industry
38	Sweden	Telefonaktiebolaget L. M. Ericsson (n.d.), *Welcome to the smart factory* Retrieved on 13.05.2018, from: https://www.ericsson.com/en/cases/2017/smartfactory		Focus on mass-customization, effectiveness and wireless connections

Appendix 2 - Interview Questions

Interview questions about Industry 4.0 and HR

HR Practices

1. In what way do you think Industry 4.0 will have an impact on HR practices?
2. What practices will be most influenced by Industry 4.0 and why?
3. What practices need to be changed /adapted most in your opinion and why?
4. In what way do you think new practices will be established and why?
5. Which practices will become more important and which will become superfluous and why?
6. In what way do you think the practices are impacted for different sectors?
7. In the Industry 4.0 documents most countries talked about education and training being important. In what way do you see this?

HR Managers

1. What do you think will be the main changes for hr managers caused by industry 4.0?
2. What will be the main issues with the implementation of industry 4.0 and what do you think would be the best way to counter those obstacles? Would these differ per country? If so, what would cause these differences?
3. On a side note, what do you think will be the biggest changes for hr-managers in the coming years that are not related to industry 4.0?
4. How would the role of hr managers change over the coming years if industry 4.0 were not to happen?
5. What is the greatest asset hr managers would gain by industry 4.0 and what would be the biggest loss?
6. What do you think would be the main differences between the early adopters and those lagging behind?
7. Which type of companies/industries do you expect to be amongst the first to adopt industry 4.0? (and why)
8. Which strategies do you expect companies either unwilling or unable to adopt industry 4.0 to pursue?

Line Managers

1. How, based on the framework, would you define the future role of line managers?

2. What will be the main differences to current tasks line managerss have to perform?

3. Based on the framework and its streams: In which stream will the role of line managers be most influential or change the most?

4. In what way would you expect the employee-line manager relationship to change?

5. In what way will the new technologies influence the work of line managers? Do you regard this as positive or negative changes? Why?

6. How do you think the typ of supervision will change due to new technologies?

7. What would be the best way to manage people/teams in the context of Industry 4.0, from a line-managers perspective?

8. Industry 4.0 also brings a lot of changes concerning communication(technologies). How do you think that will affect the work of line-managers?

9. Which knowledge and skills do you think line-managers will have to accomplish to perform in Industry 4.0?

10. Which learning and training methods do you think are the most useful in communicating and teaching the needed knowledge and skills?

11. How would you describe the character, personality-traits and skills of a line manager in Industry 4.0.