

Industry 4.0 – Achieving competitive advantage by being an early adopter

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ABSTRACT

The concept of Industry 4.0 has been an important topic among manufacturing companies and researchers since it was first introduced in 2011. Companies have now started to realize its importance and how it will change their industries in the future. Therefore, companies have started to study this concept to understand the benefits and improvements it can bring to them. While companies are making plans for this concept of Industry 4.0, they have also one important decision to be made, to be among the first ones to implement these technologies or not and just follow the actions of their competitors. This paper is aimed at providing information for this decision with insights from six different supply chain professionals combined with existing literature. The analysis between interview findings and the theory shows the benefits of Industry 4.0 technologies are mainly related to improved efficiencies within supply chain with less human participation, which leads to a higher ability to compete with other companies and to a positive impact on the growth rates of the company. Majority of the interviewees believe it is better to be among the first ones to implement Industry 4.0 technologies, as it creates competitive advantage for the company and because being one of the last adopters would become a barrier for operating the business. Therefore, being one of the last adopters can negatively influence the company, while successful early adoption of these technologies can lead to benefits no other company in their industry have yet achieved.

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Keywords

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1. INTRODUCTION

The manufacturing industry has faced many new innovations and emerging technologies over the last decades and centuries. These disruptions have ranged from the innovation of the steam engine to the electrification to the World Wide Web and lately to the cyber physical systems, machine-to-machine communication and to 3D-printing to name a few. These innovations are related to the Industrial Revolutions which is discussed more in detail in the next section. For companies these new disruptive technologies can be an important source of competitive advantage, but in order for that to happen, companies need to fully understand the particular technologies and how they can improve their business operations. While working on the implementation strategies for the selected technologies, companies need to decide as well whether to be one of the early adopters of a particular technology or be part of the late majority of companies who will implement it. In order to make this decision, companies need to understand the benefits and dis-benefits of belonging to each of those categories. This paper is aimed at providing background information for this decision.

1.1 Industrial revolutions

So far there has been four industrial revolutions. The First Industrial Revolution began in England in late 18th – early 19th century, which was triggered by the construction of railroads and the invention of the steam engine which ushered the mechanical production (Schwab, 2017). It was also influenced not only the development of science and technology, but also the change of the structure of society, urbanization and emergence of new specialties (Popkova, Ragulina & Bogoviz, 2018, p. 13).

In the 20th century the Second Industrial Revolution began and was connected to electrification and organization of conveyor production, which made mass production possible (Schwab, 2017). During this revolution the labour efficiencies grew and approaches to corporate management changed as well (Popkova, Ragulina & Bogoviz, 2018, p. 14).

In the 1960s the Third Industrial Revolution began, and it is usually called the computer or the digital revolution, because it was catalysed by the development of semiconductors, mainframe computing, personal computing and the Internet (Schwab, 2017). This revolution included complex transformations of systems, structures, institutes, relations and technologies which changed the means, mechanisms and contents of people's organizing production, exchange, consumption, training, communication and leisure (Popkova, Ragulina & Bogoviz, 2018, p. 17).

The Third Industrial Revolution, based on the computerization of business processes and information technology supporting manufacturing, has moved into a fourth wave, which has begun to be dominated by intelligent (smart) products, 3D printers or autonomous vehicles (Witkowski, 2017, pp. 768). This fourth wave is described as the Fourth Industrial Revolution, which is also known as the "Industry 4.0". The term itself was formed by the German National Academy of Science and Engineering and its working group founded on the Hanover exhibition in 2011 (Kagermann, Wahlster & Helbig, 2013). The key drivers of this revolution are the increased integration of "Cyber Physical Systems" into factory processes (Alur, 2015) and the Internet of Things, Smart Factory (Hermann, Pentek &

Otto, 2016, pp. 3928-3937) and Big Data (Witkowski, 2017, pp. 768). These concepts are discussed more in detail in the chapter 2.2 of this paper.

1.2 Problem Statement

The Industry 4.0 is a growing topic among researchers, it is expected the realization of this vision may take 10-20 years from the year 2011 (Witkowski, 2017, pp. 768). The benefits of implementing Industry 4.0 technologies and applications have already been researched and many companies are realizing those benefits already. Increasingly more companies are developing their strategies for Industry 4.0, when and what technologies to implement and are thinking how they could improve their businesses overall with them. However, there is a gap in the literature done. The gap consists of what type of benefits the early adopters of Industry 4.0 can achieve compared to those companies who implement Industry 4.0 technologies later, so called late majority and laggards in the technology adoption curve. When to implement Industry 4.0 technologies is an important decision for every manufacturing company, which is why this paper aims to fill the gap in the academic research done.

1.3 Research Question

As technology keeps improving with a fast pace, companies have to come up with plans on which technologies to implement and how to approach all these new innovations. Some companies are the actual innovators of the technology, some companies decide to be early adopters of the technology, some decide to be early majority, some late majority and the remaining companies can be described as laggards (Rogers, 1962, pp. 22). It is important for a company to understand in which category they should be in, as the benefits and costs differ per category (Hall & Khan, 2002, pp. 4).

There has been research done about the benefits of implementing Industry 4.0 technologies and some of these benefits are increases in revenue, productivity and ability to compete (Barreto, Amaral & Pereira, 2017, pp. 1247). But there is a lack of research about the benefits specifically for early adopters of Industry 4.0 technologies compared to the late majority and laggards. There has been research done about the general benefits of belonging to different categories in the Diffusion of Innovations model, but these theories have not been implemented specifically for Industry 4.0. Therefore, the main research question for this paper is:

To what extent can the early adoption of Industry 4.0 technologies affect the future growth of a manufacturing company?

1.4 Sub-research Questions

To be able to answer the main research question, it needs to be divided into different sub-questions, which are as follows:

To what extent is Industry 4.0 already implemented within different industries?

This question is of importance as it helps to understand to what extent Industry 4.0 technologies have been implemented in different industries and if the answers to the following sub-questions differ between companies from different categories on the implementation curve.

What type of benefits or none have companies already realized from the implementation of Industry 4.0?

After finding out to which category certain company belongs to, it is needed to find out what type of benefits they have achieved from the implementation of Industry 4.0 technologies, which allows the comparison of these findings with the theory.

What are the desired goals companies want to achieve with Industry 4.0?

It is needed to understand the reasons behind why companies want to implement these new technologies, as this will help in understanding the consequences of not implementing any.

What types of risks there are for companies if they are one of the last adopters of Industry 4.0?

This question helps to understand the risks of being one of the last adopters, which is valuable information for this paper and for answering the main research question.

What are the reasons for a company to be an early adopter of Industry 4.0 technologies instead of being part of the late majority and laggards ?

This question is aimed at getting professional insight from the interviewees about their opinions on being an early adopter, which directly helps with answering the main research question.

2. THEORY

2.1 Technology adoption

One of the relevant theories for this research is the Diffusion of Innovations model by Everett Rogers, which concerns the rate at which technology is adopted and spreads. According to this theory, the rate of adaptation is categorized into five different categories, innovators, early adopters, early majority, late majority and laggards (Rogers, 1962, pp. 22). These categories can be seen in the Figure 1 below.

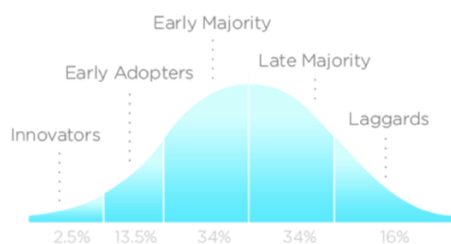


Figure 1. Technology adoption life cycle. Retrieved from https://en.wikipedia.org/wiki/Technology_adoption_life_cycle

Innovators are the first users of a new emerging technology and this category includes the innovator itself. The innovators are only a very low percentage of the whole market and they are able to cope with higher levels of uncertainty about an innovation compared to other adopter categories (Rogers, 1962, pp. 413). It is crucial for innovators to have viable financial resources, so that they can survive any potential loss incurred from an unsuccessful innovation (Information Resources Management Association, 2018, pp. 833). The early adopters can be described as the visionaries, which represent a strategic segment of the adopters, because they are the most willing to invest time and resources to the

innovation to test it (Valdani & Arbore, 2013). As the early adopters are not the innovators, they have the ability to reduce the extent of uncertainty of the innovation by implementing it and they help in motivating the masses when they incorporate an innovation (Information Resources Management Association, 2018, pp. 833). Which also means that the early adopters can also be seen as the trendsetters for the market/industry (Rogers, 1962, pp. 22). Early majority group is the largest of the adopter groups as they represent third of the members of any system. They function as the most important link between very early and comparatively late adopters. They spend relatively longer time in taking their innovation adoption decision compared to the innovators and early adopters (Information Resources Management Association, 2018, pp. 833). Late majority comprises of the same percentage of members as the early majority (one-third). The adoption of this category is affected by several factors like economic necessity and/or competitive pressures of those who are part of the same industry (Information Resources Management Association, 2018, pp. 833). Laggards are the last ones to adopt a new innovation as they are sceptical about innovations and change agents. This group does not have too much awareness and knowledge of the innovation and the reason they give for this is, that they have limited resources (Information Resources Management Association, 2018, pp. 833). This means laggards are also often forced to implement an innovation, as they can even be resistant to them (Rogers, 1962, pp. 413).

This model can be used to show the technology adaptation amongst society, but also for companies. Especially for companies, technology adoption is seen as important because with it is possible to gain competitive advantage for two primary functions: 1) for supporting the business processes to produce products or services which are cost-effective and 2) for the time savings through the improvement of productive yields (Ramayah et al. 2013, pp. 104). The nature of the innovation itself is also important, as the more complex and costly the innovation is, the more likely is that firms will differ significantly in their understanding and in the risk they attach to adoption (Davies, 1979, pp. 126).

2.2. Industry 4.0 and its benefits

Now the term Industry 4.0 needs to be defined and its benefits. There is no one widely accepted definition for the concept, but mainly it is comprised of the integration of the production facilities, supply chains and service systems to enable the establishment of value-added networks. Thus, emerging technologies such as big data analytics, autonomous (adaptive) robots, cyber physical infrastructure, simulation, horizontal and vertical integration (Ustundag & Cevikcan, 2018, pp. 3). Industry 4.0 can also be defined as a system which introduces smart products, which capture major data holdings due to significantly increased compute and memory performance and can evaluate and can identify itself to higher-level systems (Schmidt et al. 2015, pp. 24). In short, Industry 4.0 aims at enabling communicating, intelligent and self-controlled systems (Anderl, 2014, pp. 3).

The main key driver of this revolution is increased integration of "Cyber Physical Systems" into factory processes (Alur, 2015). Other key drivers include concepts as Internet of Things, Smart Factory (Hermann, Pentek & Otto, 2016, pp. 3928-3937) and Big Data (Witkowski, 2017, pp. 768).

Cyber Physical Systems

Industry 4.0 intertwines physical and digital processes, which refer to the Cyber Physical Systems (Schmidt et al. 2015, pp. 1). The term cyber-physical systems (CPS) itself refers to a new generation of systems with integrated computational and physical capabilities, that can interact with humans through many new modalities. The embedded computers and networks will monitor and control the physical processes, with feedback loops where physical processes affect computations and vice versa (Roblek, Meško & Krapež, 2016, pp. 4). The ability to interact with and expand the capabilities of the physical world through computation, communication, and control is a key enabler for future technology developments (Baheti & Gill, 2011). In simple terms, cyber-physical systems are systems which have an interface between the digital (cyber) world and the real (physical world). A simple example is sensors, with their own IP address (Sauter et al., 2015, pp. 4).

Internet of Things

The concept of Internet of Things was created by a British entrepreneur Kevin Gaston in 1999 to describe a system in which material world communicates with computers with ubiquitous sensors (Witkowski, 2017, pp. 766). Generally, Internet of Things can be defined as the Internet connection between everyday physical objects in the shop floor, people, systems and IT systems, creating a smart manufacturing environment often referred as smart factory (Shariatzadeh et al. 2016, 512-517). This means, that the objects in the physical world communicate with the digital world by becoming connected objects (COs) with enhanced functions. COs and devices make it possible to store transmit and process data taken from the physical world, touching many aspects of human life such as food, agriculture, industry, health, sports to name a few (Bouhaï & Saleh, 2017, pp. 21). A simple example is making home appliances, such as a fridge part of the Internet environment, which now allows it to communicate with other connected home appliances (Buyya & Dastjerdi, 2016, pp. 1). This means the functions of one product can be further enhanced, if it is connected to related products and thus becomes part of a product system (Wortmann & Flüchter, 2015, pp. 222).

Smart Factory

In a smart factory, production capacities start interacting with manufactured goods and adapting to the new needs of consumers. At that, the whole stages of production are formed without human participation and will be deepened in this direction. This is the production part of Internet of Things, which quickly enters the life of consumer society. (Popkova, Ragulina & Bogoviz, 2018, p. 17). Without human participation means the factories have capabilities of self-awareness, self-prediction, self-comparison, self-reconfiguration and self-maintenance (Lee, Kao & Yang, 2014, pp. 4). This means, that each physical component and machine will have a twin model in the cyberspace composed of data generated from sensor networks and manual inputs. Intelligent algorithms process the data in the cyberspace, so that information about the physical components' health condition, performance and risks are calculated and synchronized in real time. The smart machines use real-time data from their own components and other machines to gain self-awareness and self-comparison. This self-awareness enables machines to assess their own performance and to diagnose possible malfunctioning components. The machines can also predict and prevent potential failure and risk contributions to the final product. The machines can share

their information over the cyberspace to compare their performance and productivity with other similar machines. With this self-comparison the manufacturing system is able to schedule customized manufacturing criteria for individual machines based on their performance (Lee, 2015). This means that smart factories are flexible and reconfigurable, low cost, adaptive or transformable, agile and lean (Radziwon et al. 2014, pp. 1187). Therefore, the smart factories will be evolutionary, disruptive, change the way people work and will massively improve the supply chain of a manufacturing company on a scale not seen in any industry before (Kent, 2018, pp. 305-324).

Big Data

Today there is a tremendous amount of data generated every day in the sectors of manufacturing, business, science and our personal lives. Proper processing of the data could reveal new knowledge about our market, society and environment, and enable us to react to emerging opportunities and changes in a timely manner (Chen et al. 2013, pp. 157). However, the growth of the data volume in our digital world seems to out speed the advance of our computing infrastructure. Due to such large size of data, it becomes very difficult to perform effective analysis using the existing traditional techniques (Katal, Wazid & Goudar, 2013, pp. 404). There is a technology by which we can conduct analysis on the massive amounts of data and that is Big Data. Big Data allows us to quickly and efficiently manage and use this constantly growing database. This tool allows analysis and separation of the important from the less important – helping to draw conclusions and support effective transfer of knowledge to carry out business objectives (Witkowski, 2017, pp. 767). Efficient capture and analysis of big data has the potential to enhance productivity with resulting competitiveness in a wide range of industrial sectors. From the point of view of manufacturing engineers, supply chain management can be improved via big data solutions (Yin & Kaynak, 2015, pp. 144).

Benefits of Industry 4.0

Looking at the benefits, the fourth industrial revolution brings many positive changes to today's manufacturing, including mass customization, flexible production, increased production speed, higher product quality, decreased error rates, optimized efficiency, data-driven decision-making, better customer proximity, new value creation methods and improved work life (Kusmin, 2017, pp.1). Other benefits include increases in safety and transparency (Boyes et al, 2018, pp. 2). Next to these, other benefits associated from implementing Industry 4.0 systems are increased productivity, increased competitiveness of businesses, increased revenue, increased employment opportunities, enhanced human and IT resources management, optimization of manufacturing processes, development of exponential technologies and delivery of better customer service (Gilchrist, 2016, pp. 206). Industry 4.0 also ensures creation of better cooperation between employees and business partners (Sanders, Elangeswaran & Wulfsberg, 2016, pp. 816).

These benefits are achieved as Industry 4.0 technologies enable manufacturing ecosystems driven by smart systems, that have autonomic self-properties, for examples self-configuration, self-monitoring and self-healing (Thames & Schaefer, 2017, pp. 2).

In short, Industry 4.0 brings many new possibilities for manufacturing companies to improve their businesses and operations. It is up to a particular company to select which

available technologies and systems are the most suitable for them.

3. RESEARCH METHODS

At the beginning of this research, desk research has been done about the Industry 4.0 and about the diffusion of innovations to get an understanding of these topics. The sources for this information are websites such as Google Scholar, Scopus, Web of Science and Sciencedirect. The keywords used for the searches are as follows: Industry 4.0, Industry 4.0 benefits, technology adoption, innovation early adopters and a few variants of them. For the research of Industry 4.0, it is decided to not use information sources before 2010, in order to only use the most up-to-date information available. For the topic technology/innovation adoption there is no limitations as for the Industry 4.0.

Afterwards gaining knowledge of these two topics, some questions for the interviews were constructed in order to ultimately answer the main research question of this paper. For this research, 6 different Supply Chain Managers / Plant Managers were interviewed, as these are the people who have an understanding of the Industry 4.0 concept. The interview questions were aimed at getting better understanding of Industry 4.0 within manufacturing companies, such as about the benefits, risks and about the opinions of being an early adopter. Interviews were organised individually, either over a phone call or a face-to-face meeting. Interview was seen as a better method for this research over surveys, as interviews allowed discussion about each individual question, which helped to gather better insights about the topic.

After the interviews, the data was analysed using tables in chapter 5, which leads to the conclusion of this paper and to the answer of the main research question.

4. DATA FROM THE INTERVIEWS

4.1 Interviewee A – being an early adopter of Industry 4.0 technologies impacts the ability to compete with others

Works as a Vice President Supply Chain and Operations for a company, which operates in the food industry in Finland. The interviewee states they are currently in the planning phase of implementing Industry 4.0 technologies, meaning they are exploring the opportunities within the concept and calculating the costs and benefits of these new technologies. The interviewee believes Industry 4.0 will bring more transparency to the whole supply chain and eventually for the end-user of their products. Other benefits stated are better management of inventories and warehouses. Industry 4.0 will also help with the maintenance of their machinery as the sensors within their machines inform when a machine needs to be repaired. Next to these benefits, Industry 4.0 also enables the company to be more cost-effective within their supply chain. When it comes to being an early adopter, the interviewee believes it has a big influence on the ability to compete. They aim to be part of the early majority in the technology adaptation curve, but not the very first ones, so called innovators. As for the risks of being among the last adopters, the interviewee states it can become a barrier for operating a business when a company is among the last ones. This is because the company would be in a weaker position to compete against their competitors and providing value for

their customers. This eventually could lead to a loss of sales volumes and customers.

4.2 Interviewee B – company needs to have functioning sales processes to sell the increased production volumes

Works as a Supply Chain Manager for a company in Finland, which manufactures clothing for children. This company does not have their own factories, they have outsourced their manufacturing processes to a different company. According to the interviewee, their manufacturing partner does not have Industry 4.0 technologies implemented. The interviewee also states their competitors have not implemented these technologies yet either, however companies which manufacture working clothes for the employees of hospitals have some of those technologies implemented within their manufacturing processes. When it comes to the benefits of Industry 4.0 technologies, the interviewee believes they will bring efficiency for the whole supply chain when the suitable technologies have been implemented for a specific company. Having more efficient supply chain enables company to have higher manufacturing volumes, which will lead to a higher revenue, if the company is able to sell the higher number of products. Next to these benefits, Industry 4.0 will also bring transparency for the supply chain, which can help to resolve some bottlenecks in their operations. When it comes to the risks of being one of the last adopters, the interviewee believes it can result in the loss of ability to compete with other companies, loss of market share and eventually lead to a negative impact on the profitability of a company. The interviewee believes it is better to be part of early adopters in the technology adaptation curve, when the company has the ability to sell the higher number of products. If the company does not have this ability, it is better to be part of the so-called late majority.

4.3 Interviewee C – planning together with partner companies on how to implement Industry 4.0 technologies strengthens the business relationship between them

Works as a Plant Manager for a company, which operates in Finland in the packaging industry. They are currently in the planning phase of implementing Industry 4.0 technologies and they have implemented some individual parts of technologies, which could be described as Industry 4.0, but not complete systems. The interviewee believes there are couple of pioneering companies within their industry who are a bit ahead of them in terms of implementing these systems, but the interviewee believes they are still part of the early adopters. However, some of those pioneering companies can be a large global companies. The company interviewee C works for is privately owned and smaller than the pioneers. Therefore, the interviewee states they are faster in the decision-making and in the implementation phase itself, which can eventually make them ahead of their competitors. When it comes to the benefits of Industry 4.0 technologies, the interviewee believes these technologies improve the utilization rates of the manufacturing machines, which eventually leads to the growth of the company. Other benefits are real-time information of a product, as where it is at each given point of time within their supply chain. This will bring more transparency and value for the end-customer, as they can see where their product is currently located. Also, when

the company is planning with its customers on how to implement these new technologies and together making strategies for them, this strengthens the relationship between them, which creates a barrier for other companies to come and break that customer relationship. When it comes to the risks of being last adopter, the interviewee states few examples as losing the ability to compete, slower decision-making and having to always explain to their customers why they have not implemented these technologies like their competitors have, which can have a negative impact on the relationship between them and their customers.

4.4 Interviewee D – in some industries the benefits of Industry 4.0 technologies are related only to the service side of their products

Works as a Director of Supply Chain Development for a company, which operates in the solar thermal energy industry in Finland. The interviewee stated they do not have Industry 4.0 technologies implemented within their manufacturing processes and believes their competitors do not have either. Within this industry the benefits of Industry 4.0 are related to the service side of their business, this means with better and larger amount of data and information they are better able to plan and design their solar collector fields. This helps to improve their offers to the prospective customers and make cost-calculations with better accuracy. Moreover, the benefits are only related to the product development. This is because the whole industry is relatively new, their competitors and customers are still learning about the whole product and industry itself, which means the companies currently operating in this industry do not compete with having an efficient supply chain, they are mainly competing with other aspects as services related to their products. This means the implementation of Industry 4.0 technologies would not have a direct impact on the growth rates of a company. When it comes to the risks of being one of the last adopters of Industry 4.0 technologies, the interviewee states there are currently low risks involved, as the companies within this industry do not compete with each other with those technologies but agrees this can change in the future. The interviewee believes one of the most important reasons to be an early adopter of Industry 4.0 technologies is related to branding, as the whole concept is such a big topic currently, lots of money and time is invested into it. Having the knowledge and know-how about Industry 4.0 is beneficial, as it can help with the product development and through it a company can achieve higher ability to compete. Having those skills is important, as in today's business environment it is difficult to achieve competitive advantage just by having an efficient supply chain.

4.5 Interviewee E – in some industries it is needed to be always an early adopter of new technologies as “the winner takes it all”

Works as a Director of Supply Chain PMO for a company, which offers electronics manufacturing as a service in Finland. The interviewee states because they are providing electronics manufacturing as a service for companies whose products are designed to be used in enabling technologies such as 5G networks and the Industry 4.0, they have to have understanding of these concepts and have them implemented

within their own manufacturing processes. Also, the competition is so fierce between the companies operating in this industry, that every company wants to be an early-adopter and achieve higher manufacturing efficiency than their competitors. This is because the customers of these companies are outsourcing the manufacturing processes and they expect cost-efficiency. The company which is ahead of their competitors in terms of efficient manufacturing will be the most successful, as the interviewee stated, “the winner takes it all”. When it comes to the benefits of Industry 4.0, the interviewee states more efficient production and through it the profitability of company increases. Therefore, the implementation of these technologies will also have an impact on the growth rates of a company. Other benefit mentioned is gaining higher ability to compete with companies, which come from different countries where for example the costs of employing are low, when they are themselves located in a country, where these employing costs are high. When it comes to the risks of being one of the last adopters, the interviewee believes within this industry the company will eventually run out of business as their competitors are able to offer better value and cost-efficiency. Other risks involved with the implementation of these new technologies is that the wrong investments for a specific company are made, that the investment do not improve the operations, or the money could have been used better for some other technology.

4.6 Interviewee F – implementing Industry 4.0 technologies directly impacts the growth rates of a company

Works as a Supply Chain Director for a company in Finland, which manufactures electrically conductive plastics to be used in different industries. The interviewee states they have one system through which they operate their whole manufacturing processes and get the combined data from, but currently they are not planning on implementing technologies which can be described as Industry 4.0. However, the interviewee believes this will change in the future. When it comes to the benefits, the interviewee states transparency for the supply chain as one of the most important ones. Transparency also brings faster reaction times and through it more efficient supply chain as well, which impacts the profitability of a company. The interviewee also states, that the implementation of these technologies will have a direct impact on the growth rates of a company, as currently the manufacturing machines have been running at their full capacities and with these technologies it is possible to increase the capacity without increasing the number of machines. This increases the production volumes and eventually the revenue of the company. When it comes to the risks of being one of the last adopters, the interviewee states risk as losing the ability to compete with other companies, as the customers' requirements are higher year by year and if a company is not able to meet them, this will lead to loss of customers. Therefore, the interviewee believes it is better to be an early adopter and together with their customers to plan and strategize on how to benefit from these emerging technologies, as this strengthens the relationship between them. This generates a barrier for other companies to break the customer relationship, which creates a stronger foundation for the business to operate on.

5. ANALYSIS OF THE INTERVIEWS

The interviews consisted of 6 different professionals with the following job titles (1) Vice President Supply Chain and Operations, (3) Director of Supply Chain, (1) Supply Chain Manager and (1) Plant Manager. The interviewees work in the following industries: food, clothing, packaging, solar thermal energy, electronics manufacturing and plastics manufacturing. The interviewed professionals and the companies are located in Finland.

The companies were chosen, because they all are manufacturing companies and operate in different industries, as this gives more insight and broader look about the implementation of Industry 4.0, than interviewing companies and professionals from the same industry.

One of the interviews was organised as a face-to-face meeting, other professionals were interviewed over a phone call. During the interviews notes were made and one of the interviews was audio recorded as well. Based on the notes and audio recording, the following analysis of the interviews has been made:

5.1 Majority of companies believe they are in the same phase as others in terms of implementation of Industry 4.0 technologies

Interviewee	A	B	C	D	E	F
In the planning phase	X			X		
Individual pieces of technology			X		X	X
Complex systems						
Ahead of competitors						X
Same phase as majority in the industry	X	X	X	X	X	
Not implemented		X				

When it comes to the implementation of Industry 4.0 technologies, most of the interviewees (5/6) answered they are in the same phase as majority of the companies within their industries. Only one, interviewee F stated they are ahead of their competitors. Most of the interviewees also stated they are currently planning on what Industry 4.0 technologies to implement or have implemented some small individual pieces. One interviewee (B) stated they have not implemented any Industry 4.0 technologies. This is because they are currently outsourcing the manufacturing of their products. Therefore, it can be concluded all companies which have their own manufacturing plants have started to implement these new technologies and if they are not, they are planning on doing so in the near future.

5.2 Transparency, cost-efficiency and positive impact on growth rates are the most common benefits from the implementation of Industry 4.0 technologies

Interviewee	A	B	C	D	E	F
Transparency	X	X	X			X
Better inventory management	X					
Cost-efficiency	X	X	X		X	X
Higher utilization rates of machines			X			
Improvement on the service side of the product				X		
Competitive advantage					X	X
Positive impact on growth rates	X	X	X		X	X
Improvement in product development				X		

When it comes to the benefits of Industry 4.0, most of the interviewees (5/6) stated cost-efficiency, which was the most popular answer among bringing more transparency to the supply chain, which helps in finding the bottlenecks within the production and giving more information for the end-consumer. Majority of the interviewees (5/6) also believe the implementation of these technologies will have a positive impact on the growth rates of a company. The interviewee D did not answer this as they operate in the solar thermal energy industry, where the companies are currently not competing with these technologies. The companies within that industry compete with other aspects of their products. The interviewees E and F also stated Industry 4.0 will lead to competitive advantage. These answers are in line with the theory, which was provided in the section 2.2 of this paper.

5.3 Most companies implement Industry 4.0 technologies to achieve cost-efficiencies within their manufacturing processes

Interviewee	A	B	C	D	E	F
Higher market share	X	X				
Transparency	X		X			
Cost-efficiency	X		X		X	
Faster production speed		X				
Improve product development processes				X		
Increase the rate of automation within supply chain						X
Improve profitability			X		X	

Most popular answer regarding the targets what companies want to achieve with the implementation of Industry 4.0 technologies was cost-efficiency, as 3/6 interviewees stated it. The second, third and fourth most popular answers were transparency, higher market share and improvements in the profitability of a company.

5.4 Loss of revenue, customers and lowered ability to compete are the most common risks for being one of the last adopters of Industry 4.0

Interviewee	A	B	C	D	E	F
Becomes a barrier for doing business	X		X		X	
Loss of customers	X	X			X	X
Lower ability to compete	X	X	X		X	X
Loss of revenue	X	X			X	X
Small or non-existent risks				X		
Slower decision-making			X			

When it comes to the risks of being one of the last adopters of Industry 4.0 technologies, most popular answer was the lowered ability to compete with other companies within their industries. The interviewee D did not answer this as within their industry, the companies currently compete with other aspects related to their businesses. The second and third most popular answers were the loss of customers and a loss of revenue, which are linked together as the loss of customers can lead to a lowered revenue. Three respondents also stated becoming one of the last adopters of Industry 4.0 will become a barrier for business, as in this situation the company would always have to explain to its customers why they do not have those technologies implemented when all their competitors do. This can have a negative impact on the relationship between the company and its customer.

5.5 Gaining competitive advantage is the most important reason for companies to be an early adopter of Industry 4.0

Interviewee	A	B	C	D	E	F
Competitive advantage	X			X	X	X
Increases in growth rates		X				
Strengthen customer relationships			X			X
Branding				X		X
Requirement to operate in the industry					X	

The most popular answer for the reason to be an early adopter of Industry 4.0 was gaining competitive advantage. The second most popular answer was, that it strengthens the current customer relationships. This is when the company plans together with its customer on how to benefit from the Industry 4.0 technologies, makes strategies for them and together are implementing those plans. This enforces the bond between them and creates a barrier for other companies to come and break that customer relationship. This will in turn help the company to have a solid foundation for doing business. Branding also had 2/6 answers, because currently the Industry 4.0 is such a big topic and a lot of money and time is invested into it. When a company has implemented

these technologies, they can use it as their benefit in marketing.

6. CONCLUSION

Questions	Main findings
Implementation of I4.0	Same phase as majority in their industries, have implemented individual pieces of I4.0 technologies and are in the planning phase
Benefits of I4.0	Cost-efficiency, positive impact on growth rates and more transparency
Goals to achieve with I4.0	Cost-efficiency, transparency, higher market share and improved profitability
Risks of being one of the last adopters of I4.0	Lower ability to compete, loss of customers, loss of revenue and being one of the last ones to implement becomes a barrier for doing business
Reasons to be an early adopter of I4.0	Gaining competitive advantage, strengthens customer relationships and for branding purposes

As seen in the table above, majority of the companies have already started making strategies on how and which technologies to implement, that would be the most beneficial for their business. However, all the interviewed companies are still just in the beginning of this whole revolution as no industry changing technologies or systems have implemented by any of the companies. When it comes to the benefits of Industry 4.0, transparency was one of the most popular answers and it was provided in the literature (Boyes et al, 2018, pp. 2). Cost-efficiency and positive impact on growth were also the most common answers for the benefits, which were provided by the literature as well (Gilchrist, 2016, pp. 206). Majority of the interviewees believe being one of the last adopters of these technologies will become a barrier for operating the business, leading to losses in the ability to compete and in providing value, which will eventually lead to loss of customers, lowered revenue and loss of business in the end. Therefore, the majority of the interviewees believe it is better to be among the early adopters to gain competitive advantage, to first achieve the benefits of Industry 4.0 before their competitors. They also believe being an early adopter will strengthen the customer relationship, when both the company and the customer are together planning for the best use of Industry 4.0 technologies and together implementing those strategies. This helps to create a solid foundation for operating the business. This insight is a new finding, which has not been covered in the literature. Being an early adopter can also help with the branding of the company, as Industry 4.0 is such a big and trendy topic currently. This finding is also new, as it was not provided by the literature of this research. With this information the main research question of this paper can be answered.

To what extent can the early adoption of Industry 4.0 technologies affect the future growth of a manufacturing company?

Being among the first ones to implement these technologies in their industries can lead to an increased growth and competitiveness of the company. Being an early adopter will also have a direct impact on the future growth rates of a company, when the product of a company has the demand for the increased production volumes. Next to this, specifically in

the business-to-business markets, when a company together with its customers makes plans for the Industry 4.0 and implements them, this strengthens the relationship between these two. This helps to build stronger foundation for doing business, even though this benefit cannot be measured in monetary terms.

Next to these reasons, being part of the late majority or laggards can become a barrier for operating the business, which can over time lead to losses in revenue and threaten the existence of a company. However, if the companies in one industry do not compete with having Industry 4.0 technologies implemented and with cost-efficiencies or the company knows their product does not have the demand for the increased production, there is no need to be among the first ones. In this case it is enough to “stay with the masses”.

Therefore, it can be concluded that early adoption of Industry 4.0 technologies can positively impact the growth rates of a company. This happens when the company knows their products will sell and the implementation of these technologies greatly improves the company’s ability to compete. Successful implementation of Industry 4.0 technologies in this case will lead to benefits no other competitor in their industry have yet achieved.

7. LIMITATIONS AND FUTURE RESEARCH

As only 6 supply chain managers from different industries were interviewed for this paper, the opinions and data received during those interviews will not give complete information about the difference between benefits for early adopters and to late majority/laggards in every industry. Also, as the interviewees were from Finland, there will be some limitations for the geographical area. Therefore, the opinions and results will not be applicable worldwide. Next to these, the way the questions were structured and phrased may cause some form of bias among the responders.

To fully answer the main research question, more comprehensive research will be needed for the results to be proven accurate. The further research could include larger sample size, increased geographical area and the research could cover more industries. It is also possible to compare the results between countries to see if there are any differences. This type of research allows identifying the situation of Industry 4.0 more accurately in a global setting.

8. CONTRIBUTION

This research contributed to the study of Industry 4.0 in the following ways. First, it fills the gap in the literature regarding the benefits of implementing Industry 4.0 technologies for early adopters and what are the disadvantages of being part of late majority and laggards. Secondly, this research provides insights about the situation of Industry 4.0 from 6 different industries in Finland, which can be useful information for other professionals. The data from the interviews can also be used by other supply chain professionals in the decision making to whether to be an early adopter of these technologies or not. Therefore, this research has both literature and managerial implications.

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