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Industry 4.0 and its impact on businesses

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Prohlašuji, že jsem práci zpracoval(a) samostatně a použil(a) jen uvedených pramenů a literatury.

Plzeň, duben 2019 ………………………

Poděkování

Tímto bych rád poděkoval vedoucí mé bakalářské práce Bc. Janě Havlíčkové, M.B.A. za cenné a užitečné rady při zpracování této práce a čas strávený při konzultacích.

Obsah

1 Introduction

The Fourth Industrial Revolution also known as Industry 4.0 is a phenomenon with a potential to change everyday lives of everybody and everything around us. The Fourth Industrial Revolution presents a challenge in how we understand and shape the technological revolution, which entails nothing less than a transformation of humankind. This technological revolution is already all around us, ranging from 3D printing, wearable sensors, microchips many times thinner than a single strand of hair to drones, robots and artificial intelligence capable of self-learning.[1] These technological advances affect not only our capabilities, they also affect how we live, work and interact with each other. In other words, technology is also changing what it means to be human.

I chose this topic because new technologies always fascinated me. As writer Arthur C. Clarke said: *"Any sufficiently advanced technology is indistinguishable from magic."* The marvels that we are capable of today are all possible thanks to technological advancements. Humanity has since the invention of steam engine (and thus starting The First Industrial Revolution) 200 years ago advanced more than the last 2000 years combined. The Fourth Industrial Revolution is believed to be larger in scale, scope and complexity from any other revolution that came before. Who knows what technology will change in 100, 50 or even 10 years? I find the potential of these changes fascinating and the scope of possibilities unimaginable. And since companies are already feeling the impact of Industry 4.0, I believe they are a fine subject for study of this phenomenon of 21st century.

In theoretical part I intend to focus on explanation of the term as a whole while also outlining the key technologies driving this revolution i.e. what are these new technologies, what involves their implementation, why are they important for the future of not only businesses but humankind as a whole. In practical part I will analyze the changes this revolution will have on businesses. This will be done via a survey whose goal is to gain data from the people that have certain knowledge about the company. The conclusion will be based on the data gained from this survey and will show the changes that are sure to come in the coming years.

[1] SCHWAB 2016: 1

2 Historical context

The meaning of the word revolution is simply a radical change. Every revolution stems from desire to do things differently, whether it is associated with changes in government, religion or technology. As history shows these changes usually take years to unfold, however every new revolution seems to unfold faster than the previous one (which can especially be seen in technological field).

The first event in human history that historians see as a revolution was the transition from foraging to farming around 10 000 years ago. This significant change in the way of living was made possible by the domestication of animals. This agrarian revolution enabled more effective production of food and made possible the increased growth of human population and larger settlements, which later led to urbanization and the rise of cities.

The upcoming revolutions marked the beginning of a new era. The era of industry that was made possible by these industrial revolutions that transitioned the muscle power to mechanical power. The first industrial revolution began with the construction of railroads and the invention of steam engine by James Watt in the year 1765. The revolution continued to around 1840 and ushered in mechanical production. The second industrial revolution started in the late 19th century and continued into the early 20th century, made mass production possible, fostered by the advent of electricity and the assembly line. The third industrial revolution began in the 1960s. Also called as digital revolution, this revolution was greatly influenced by the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 1980s) and finally the internet (1990). However, the effects of the second industrial revolution has yet to be fully experienced by more than 1.3 billion people, as they still lack access to electricity. Then of course the same is true about the third industrial revolution, only here the numbers are even more drastic, with about half of the world´s population, that is 4 billion people, lacking internet access. Still the emerging technologies are diffusing much faster and more widely than ever before. The spindle (the hallmark of the first industrial revolution) took almost 120 years to spread outside of Europe only. By contrast the internet was widely spread around the world in less than a decade.[2]

3 Introducing Industry 4.0

A clear definition of this term can be quite elusive. The clearest definition is in my opinion the definition by Alasdair Gilchrist in his book Industry 4.0 – The Industrial Internet of Things. Gilchrist defines Industry 4.0 as follows: *"Best understood as a new level of organization and control over the entire value chain of the lifecycle of products, it is geared towards increasingly individualized customer requirements."* The very first step in this cycle is the product idea following with the order placement. Next steps are the development and manufacturing. After that comes the product delivery for the end customer and the life of the product ends with recycling. The hallmark of this process is the availability of all relevant information by interconnecting all of the involved processes in the value chain. In other words, if one would want to define Industry 4.0 in one word it would be interconnection. This interconnection will be done via the Internet of Things which will integrate with the manufacturing environment. This is the vision of Industry 4.0, industrial businesses will form global networks to connect their factories, machinery, facilities etc. and thus creating an intelligent system connecting and controlling each other intelligently by sharing information that triggers actions. This system will improve the industrial processes within manufacturing as a whole and since through material usage, supply chains, engineering and product lifecycle management.[3]

However, this industrial revolution is not only about interconnection of systems and machines, the scope of change is much wider than that. It is also about the emerging breakthroughs in new technologies such as nanotechnology, gene sequencing, 3D printing etc. and their implementation in not only the traditional business models but also into the everyday lives of people. The fusion of these technologies across both the virtual and real world is what makes this industrial revolution fundamentally different from the previous ones.

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[2] SCHWAB 2016: 8
[3] GILCHRIST 2016: 197

If these ideas that Industry 4.0 encompasses are to succeed, it is important to realize that not only is it fundamental to upgrade technological resources like hardware and software but also to include new ways of organizational approaches, form of leadership and effectivity.

3.1 Drivers

The number of technologies that will drive this industrial revolution seems limitless as well as the applications for them and the places and spheres where they will or already are occurring. However, all these technologies have one thing in common: All of these new technologies are made possible thanks to advancements in digital power. Nanotechnology for example would not exist without artificial intelligence, which is becoming ever more relevant thanks to more efficient computing power. As was said already there are so many emerging technologies that only naming them all would be enough for a book. Here I will divide the most relevant key technologies of the future, according to a research done by the World Economic Forum, into three parts: physical, digital and biological. All of these parts are deeply interconnected and dependent on advancements made in each of them. For each technology I will list examples of this technologies used by companies or governments in practice[4].

3.1.1 Physical

In this part prevail four technological megatrends because of their tangible nature.

- 3D printing

- autonomous vehicles

- new materials

- robotics

[4] WEF 2015: 5-7

3.1.1.1 3D printing

3D printing is a process of creating three-dimensional objects based on digital model. This model is created by printing layer upon layer. Also called as additive printing it is the opposite of subtractive manufacturing, where layers are removed from a piece of material until the desired shape is made.[5] 3D printing enables to produce more complex shapes using less material than ever before. 3D printing has many applications in modern world, 3D printed prosthetics, movie props or medical implants to name a few. Thanks to 3D printing the end users will be able to do much of the manufacturing themselves rather than buying the products from other businesses, changing the nature of commerce altogether. 3D printers capable of color printing already exist as well as printers capable of outputting multiple materials and are improving rapidly. Soon even things like 3D printed electronic products will become reality. This year the first 3D printed cars were already introduced. Even as early as of 2012 first 3D printed guns were already made and the blueprints for them were soon after freely available on the internet which is now in many states of the world illegal.[6] Today the price of a 3D printer has fallen below US $1,000 and has thus found its way into households. Because of the effects on energy use, customization, mass production, medicine etc. 3D printing will no doubt change the manufacturing world as we know it.

Case study: Of all the technologies that will be listed here this one is with certainty the most widely used of them all. As was mentioned the price drop for a 3D printer has enabled even the end users to afford it for personal use. But to name a few grander examples: Mercedes Benz in Stuttgart manufactures spare parts with 3D technology. Aside from automotive industry aerospace sector also widely uses 3D printing because of increased functionality and for reducing the weight of the parts. [7]

3.1.1.2 Autonomous vehicles

When somebody thinks of autonomous vehicles, the first thing that probably comes to mind is a driverless car, however this term encompasses many more vehicles than that, today we also

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[5] SCHWAB 2016: 15
[6] ZHOU 2018
[7] YÁÑEZ 2017: 42-43

already have autonomous trucks, drones, boats, aircraft and others. All of them depend on variety of sensors such as radar or GPS to perceive their surroundings. As of today, drones are the flagship of this industry. Already commercially available not only to companies but to end users as well, this piece of technology has sparkled much interest among the population as well as controversy. For example, the owners of drones are being accused of spying on people, therefore some countries are now deploying countermeasures in form of new legislations, that forbid the use of drones for surveillance. Even the companies are starting to use this technology, for example Amazon with their Prime Air program use them for deliveries. In the future they will be able to do a number of tasks such as checking electric power lines or watering the plants in agriculture. [8]

Case study: Aside from drones the Tesla company is a great and possibly the best-known example of a company testing autonomous cars, however as with their drones cousins, the autonomous cars have recently caused a controversy when an autonomous car killed a person passing the road. Tesla´s claims that the person was not supposed to cross the road in that particular spot or that it happened on a poorly illuminated place did not help to ease the minds of many. Of all the listed technologies here, this one is perhaps currently viewed as the most dangerous.

3.1.1.3 New materials

Revolutionary materials with attributes seemingly unimaginable a few years ago are coming to market. These advanced materials vary from biomaterials to advanced new industrial ones with features like self-healing or reverting to their original. Additionally, they provide reduced weight of a product while also improving performance, survivability and affordability. Take for example graphene – a nanomaterial hundred times stronger than steel yet million times thinner than human hair and capable of efficient heat and electrical conductivity. This material could be used for lighter, thinner and stronger smartphones with better battery life.[9]

[8] SCHWAB 016: 15
[9] BROWNLEE 2016

Other new materials could play a major role in mitigating some of the global risks we face. For example, innovations in thermoset plastics could make materials, that have been considered nearly impossible to recycle, reusable as parts of new products. [10]

Case study: Today graphene is starting to appear mainly as an additive, material enhancing other products. In 2014 a Spanish company called Catlike launched a line of cycling helmets enhanced with graphene. These helmets are said to be light and strong, and offer major improvements in the field of safety and impact absorption. MediaDevil, a UK-based maker of various phone, laptop and tablet accessories, is selling Earphones with Nanene Graphene-Enhanced Audio. These earphones contain an earphone membrane that is thinner and more flexible than traditional materials can allow. [11]

3.1.1.4 Robotics

To meet consumers expectations and to keep up with the evolving manufacturing world, more and more manufacturers start employing more sophisticated use of advanced machines. This robotics serve as a means for lowering the production costs as well as managing continuous product innovation. Until recently their use was restricted especially for tightly controlled tasks in specific industries such as automotive. But today robots are increasingly used across all sectors of industry and for a wide range of tasks. In the near future this trend of cooperation between humans and machines will become an everyday reality.

In fact, this continuous change is already happening in many industries today, take for example cobots. A collaborative robot (cobot) is a robot designed to collaborate with human workers. In early research and standardization work, the main emphasis was on safety with the aim of allowing robots to work alongside humans. [12] These cobots are fully compatible with the vision of Industry 4.0. They can collect data and pass them for a future analysis via the Internet of Things, they provide technical assistance and are able to facilitate decentralized decisions.

Thanks to rapid advancements in computing power, all robots are becoming more flexible and adaptive, some are even capable of self-programming and self-learning, this technology is

[10] SCHWAB 2016: 17
[11] Graphene-info ©2004-2019
[12] ØSTERGAARD 2017: 6

called artificial intelligence (AI) and while still in its early stage of development, some examples are already available even for the end customers in their digital devices like Siri or Cortana. In 2017 some of the more advanced AI programs were already able to beat both the professional poker and video games players. [13]

Case study: Universal Robots is today considered to be the pioneer in terms of introducing collaborative robots in the industry. Universal Robots sold over 31 000 cobots to several thousand production environments around the world. The cost of an UR cobot ranges between 16 000 and 25 000 €, which added to the cost of application would total of between 50 000 and 60 000 €. This makes them an option with a relatively fast ROI (Return on Investment), when compared to the cost of traditional robots that approaches 100 000 €. [14]

3.1.2 Digital

Digital drivers are responsible for the increasing automation and the bridging of digital and physical environments. Increasing digitization is driving industries from product-based to service-based offerings. The seamless integration of the physical and digital worlds through networked sensors, actuators, embedded hardware and software will change industrial models.

3.1.2.1 Internet of Things

The Internet of Things (IoT) is one of the main bridges between physical and digital worlds. IoT is a concept of interconnection of any product with any other around it. IoT will transfer the data of all of these devices to a network without the need of a human intervention and, therefore, be more intelligent and independent. This will require the use of the IPv6 protocol instead of the now more commonly used IPv4. IPv4 is limited by the number of unique IP addresses that it can allocate to each connected device. With just a 32-bit address scheme it is able to allocate just over 4 billion addresses. Whereas the IPv6 uses a 128-bit address scheme, which translates to over 340 undecillion (39 digits) of possible IP addresses. This huge increase in address space is pivotal element in the development of the IoT because with such an enormous address space could every device on the planet be assigned with an unique IP address

[13] HARIDY 2017
[14] YÁÑEZ 2017: 56-57

and there would still be a huge reserve left for the future.[15] A remote monitoring is a possible application of the IoT. Any package can now be equipped with Radio Frequency Identification (RFID) tag that allows the company to track its movement through the supply chain and the customer to view the progress of the package.

Case study: Application of the IoT in the cities through road signs. This could be helpful for example when a car exceeds the allowed speed limit. The car would then automatically reduce speed based on the signals received from the sensors. Another possible use of IoT is Personal Protective Equipment (PPE). PPE could be designed with a build-in RFID tag (more on that in later chapters), in order to detect if an operator is using the correct PPE when working with a particular machine or within a particular workplace. [16]

3.1.2.2 Big data and advanced analytics

Big data is a term simply encompassing a huge amount of data. These sets of data are so large that traditional computer applications for data processing are unable to process them all. By Big data we mean hundreds of GB or terabytes of data collected within short amounts of time. These sets of data can be (among other things) generated by monitoring devices such as industrial cameras and wireless sensors etc. The objective to be achieved with Big Data is to make decisions in advance and to achieve maximum efficiency i.e. make decisions and actions based more on data analysis and less on experience and intuition.

It is the role of the advanced analytics to efficiently process this data. Advanced analytics is being used across industries to predict future events. Network analytics for example can use such feature to predict potential network failures and possibly prevent them altogether. The procedure of processing Big data via advanced analytics is as follows: 1) Capture. The sensors capture data (temperature, pressure, height …). 2) Transformation. Then these data are formatted and transformed (data conversions and dirty data cleaning). 3) Storage. The data get stored into databases that can store and process more information than traditional databases. 4) Analysis. For the analysis process three techniques are mainly used: a) Association – finds relationships between different variables. b) Data Mining – aims to find predictive behavior

[15] YÁÑEZ 2017 20
[16] Ibid. 23

using set of techniques that combine statistical methods and machine learning. c) Clustering – divides large groups of data into smaller groups based on similarities that were not known before the analysis. 5) Display. Usually in a form of a graph or a map.[17]

Case study: The Michelin tire company incorporates intelligent sensors called Evolution 3 into heavy machinery in the mining sector, however the technology could be applied to any type of wheel. The sensors are water-resistant and provide information about temperature and pressure. Another example is the leader of e-commerce Amazon. Their delivery system called Prime Now is able to reliably predict the purchasing desires of their customers and thus sending the product to the distribution center before the customer even buys it. [18]

3.1.2.3 RFID Tags and RTLS

RFID tags are the next generation of identifiers for tracking and identification of goods. It is a follow-up of the barcodes and like them they are instruments for a communication over short distances. However, RFID has three main advantages over barcodes: Firstly, unlike barcodes RFID does not require direct vision between transmitter and receiver. Secondly RFID can store more data than barcodes. And finally, RFID can be reprogrammed. RFID together with EPC (Electronic Product Code) will make possible the tracking of products allowing total visibility along the supply chain. EPC is a unique number placed on chip contained in an RFID tag, which allows accurate tracking of each product.

RTLS (Real-Time Location Systems) allow to effectively and accurately monitor the movement of objects in a defined space in real time. The fixed reference points receive wireless signals from the RTLS Tags to determine their location. Additionally, to RFID can RTLS be based on other technologies as well.

1) Infrared (IR). IR requires a clear line of sight for labels and sensors to communicate. If the plate is covered, flipped or damaged in any way, the system may not work properly.

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[17] YÁÑEZ 2017: 9-11
[18] Ibid. 13-15

2) Ultrasound. Because ultrasound has longer wavelengths than infrared, it is slower and therefore cannot in most instances match the performance of other technologies.

3) Wi-Fi. The accuracy of Wi-Fi is limited to up to 9 meters, which makes its value as a location tool uncertain.

4) UWB (Ultra-Wideband). UWB as a location tool has two advantages: Firstly, it has a high level of transmission security. The UWB signal is difficult to detect and locate. Secondly it can reach a precision of 10 centimeters at measuring distances of up to 100m.

5) BLE (Bluetooth Low Energy). Aside from RFID is BLE perhaps the most promising location tool. Its design can support both smartphones and low powered devices like fitness wristbands. Another advantage is that it is based on a universal standard and is therefore immediately available on mobile devices without the need for additional hardware.

Caste study: The possible applications of the RFID and RTLS transcends the use for logistics only. Take for example a smart key for a car, which would make the car recognize the key while still inside a pocket. The car would be able to open the doors or start the engine without the need for the owner´s intervention. Another possible application is the monitoring of people inside hospitals or checking for the safety of the personnel in the factories.[19]

3.1.3 Biological

Over the past half century occurred unparalleled advances in the life sciences, be it the creation of artificial limbs or even organs, new wonder drugs, stem cells etc. Most of these drivers concern the field of genomics, that allow people to live longer, healthier and happier lives.

[19] YÁÑEZ 2017: 25-27

3.1.3.1 Genome sequencing and synthetic biology

$2.7 billion was a total cost of the Human Genome Project and it took more than 10 years to finish it. Today a genome can be sequenced within a few hours and the cost dropped to less than a $1000.[20]

Synthetic biology is the next step. National Human Genome Research Institute defines synthetic biology as follows: „*Synthetic biology is a field of science that involves redesigning organisms for useful purposes by engineering them to have new abilities. Synthetic biology researchers and companies around the world are harnessing the power of nature to solve problems in medicine, manufacturing and agriculture.* “[21] In short with synthetic biology can the DNA of organisms´ be customized. While technically being the same as genetic engineering, synthetic engineering aims for more precise, efficient and easier use than previous methods. In fact, this field is not anymore so limited by technology as it is limited by regulations and ethical points of view.

Case study: The ability to edit genes is applicable to practically any cell type, which enables for modification of animal, plant and even human genes. The possible applications for the future seem limitless – ranging from the ability to modify animals ´diet so that it can be better suited to local conditions or to create food crops capable of withstanding extreme temperatures. [22]

3.1.3.2 Xenotransplantation

Xenotransplantation is a process of transplanting organs or tissue from one species to another. Such a project could not be envisaged until now because of the risk of immune rejection by the human body and also because of possible transmission of disease from animals to humans. A company called Synthetic Genomics announced in 2014 that it intends to grow genetically engineered pigs with organs that can be transplanted into human beings. Once the pig genome is modified, the embryo will be able to grow up with organs that can be later harvested and transplanted into humans. The company´s initial focus is on lungs but hopes that later it will be

[20] Genome.gov 2016
[21] Genome.gov 2018
[22] SCHWAB 2016: 21-22

possible to harvest other organs as well. Synthetic Genomics state that because of xenotransplantation the standard idea of organ donation and transplantation might cease to exist. If organs could be grown in animals, they will not be a scarce resource anymore.

Case study: Aside from growing organs, by this way it is also possible to bring back once extinct species back to life. In 2003 a team of scientists attempted to bring a once extinct wild goat indigenous to the Pyrenees Mountains back to life by implanting the DNA of the extinct goats into the wombs of 57 regular goats. One of the embryos made it to term. And while true, the goat did not live longer than several minutes after its birth, the sheer possibility has nonetheless taken hold in the minds of researchers around the world. [23]

3.1.3.3 Human Augmentation

Human augmentation also called Human enhancement is defined by IEEE as follows: „*Human enhancement attempts to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. The term is applied to the use of technological means to select or alter human characteristics and capacities, whether or not the alteration results in characteristics and capacities that lie beyond the existing human range.* “[24]

This means that through discoveries in fields such as nanotechnology or genetic engineering can the human body be improved to work better in work, sport or every day’s conditions. The utility of human augmentation does not end there however. Human augmentation could also treat illnesses such as cancer. Scientists are already working on nanobots that would be programmed with eliminating cells infected by cancer. The nanobots would simply be injected into the patient and the machines would take care of the rest. [25] However, the best example of human augmentation has been in effect for years now. Replacing missing limbs with prosthetics or bionics (a prosthetic controlled by the user´s brain) while still in its infancy is already an industry worth hundreds million of dollars. And while prosthetic or bionic limbs are still less

[23] ROSS 2016: 62-64
[24] IEET
[25] PHYS.ORG 2018

dexterous than a normal human limb, at some point the technology will offer the prospect of enhancing existing human abilities.[26]

3.1.4 Tipping Points

Some of the above-mentioned technology may seem like a science-fiction or a wishful thinking rather than something that the progress will one day make our everyday reality. These megatrends are, however, giving rise to very practical applications and developments.

A World Economic Forum published in September 2015 results of a survey on which over 800 executives and experts from the information and communications technology sector participated. The survey identified 21 shifting points i.e. moments when specific technological shifts hit mainstream society that will shape our future digital and hyper-connected world. The changes are expected to occur by 2025. Figure 1 presents the percentage of respondents who expect that the specific tipping point will have occurred by that time. These tipping points provide important context as they signal the substantial changes that lie ahead and their impact on all levels of global society. [27]

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[26] TRACINSKI 2017
[27] SCHWAB 2016: 25, 27

Figure 1: Tipping points expected to occur by 2025

Table: Tipping Points Expected to Occur by 2025

	%
10% of people wearing clothes connected to the internet	**91.2**
90% of people having unlimited and free (advertising-supported) storage	**91.0**
1 trillion sensors connected to the internet	**89.2**
The first robotic pharmacist in the US	**86.5**
10% of reading glasses connected to the internet	**85.5**
80% of people with a digital presence on the internet	**84.4**
The first 3D-printed car in production	**84.1**
The first government to replace its census with big-data sources	**82.9**
The first implantable mobile phone available commercially	**81.7**
5% of consumer products printed in 3D	**81.1**
90% of the population using smartphones	**80.7**
90% of the population with regular access to the internet	**78.8**
Driverless cars equalling 10% of all cars on US roads	**78.2**
The first transplant of a 3D-printed liver	**76.4**
30% of corporate audits performed by AI	**75.4**
Tax collected for the first time by a government via a blockchain	**73.1**
Over 50% of internet traffic to homes for appliances and devices	**69.9**
Globally more trips/journeys via car sharing than in private cars	**67.2**
The first city with more than 50,000 people and no traffic lights	**63.7**
10% of global gross domestic product stored on blockchain technology	**57.9**
The first AI machine on a corporate board of directors	**45.2**

Source: *Deep Shift – Technology Tipping Points and Societal Impact*, Global Agenda Council on the Future of Software and Society, World Economic Forum, September 2015

4 The impact of the fourth industrial revolution

The fourth industrial revolution will undoubtedly impact many areas of our every day’s lives. As with the drivers, to describe them all would be sufficient for a book of its own. However, the focus of this thesis is on business sphere and so that will be the one area that I will describe here in detail.

Empowerment will be an essential force in all of the impacted areas. For business it means the empowerment of their employees, shareholders and customers, this will be explored in the following chapters. Industry 4.0 will also transform some traditional business models. One such example is the transition from traditional factory to a Smart Factory.[28]

4.1 Smart Factory

The concept of a Smart Factory (also called Factory of the Future, Digital Factory or Factory 4.0) plays a central role in Industry 4.0. In a Smart Factory, people, machines and other resources communicate with each other as naturally as in a social network. Smart Factory also enables companies to cope with complexity and unexpected disruptions as well as to manufacture products more efficiently. [29]All of this will manifest in greater flexibility, quality, speed and communication at all levels along with significant reduction in total manufacturing costs. In a report on Industry 4.0, Tecnalia lists the six socioeconomic trends for which we have to commit for the Smart Factory at this time: the availability of new technologies, the scarcity of natural resources, adaptation to measures that favor environmental sustainability, the aging of the population and late retirement, the specialization of the staff in specific areas and finally customization.[30] Smart Factory will be both machine and human, meaning that while cobots will perform repetitive tasks and tasks of lower added value while the human element will focus on performing more specialized and complex tasks. Smart Factory will also be more intelligent and flexible – making decisions in advance and with better adaptation to customer´s needs. In

[28] SCHWAB 2016: 28
[29] BARTODZIEJ 2017: 35
[30] TECNALIA 2017

short Smart Factory is a concept of interconnected systems that together make one perfectly working and communicating organism.

4.1.1 The role of lean production in the Smart Factory

Lean manufacturing or simply just lean is a production method firstly introduced by Toyota as a Toyota Production System. It is an approach to production based on the saying the customer is always right. In lean manufacturing the entire production cycle focuses primarily on the demands of the customer with a minimal production costs and minimal waste in mind. In this case, by waste is meant the processes that use more resources than necessary. With the 4th industrial revolution the lean principles will probably be one of the main interests of companies. With a better understanding of the customer´s needs the sharing of information will be immediate and therefore the production will also be faster and will fulfill one of the lean´s objectives: to avoid overproduction and losses of time during the production process. Another objective of lean is to avoid underutilized human potential by converting manual, monotonous and repetitive tasks into supervision and control tasks. Industry 4.0 drives manufacturing models with intelligent machines and equipped with machine learning or self-learning AI, whose task is to manufacture 100 % compliant products, therefore fulfilling the last and perhaps the most important lean objective – to avoid waste and scrap.[31]

4.2 Economic impact

Experts agree that Industry 4.0 will have two major impacts on the global economy.

4.2.1 Growth

The first one is growth, however, the scale and whether the overall impact will be positive or negative is a subject to discussion as the economists are divided on that. The negative point of view is concerned about contributions of the digital revolution, claiming that the impact on productivity has already been made and the future will either bring nothing new to the table or might even make things worse. The positive point of view claims that technology and

[31] YÁÑEZ 2017: 7-8

innovation are at an inflection point and will soon unleash a surge in productivity and higher economic growth. Before the economic and financial crisis of 2008, the global economy was growing by about 5% a year. The experts expected that after the crisis the global economy would return to its previous high-growth pattern. That did not happen however, as the global economy seems to be stuck at about 3-3,5% a year. The explanations for slower global growth are many. I will only address two of them, aging and productivity, since these two are in particular interwoven with technological progress.

4.2.1.1 Aging

It is no secret that birthrates of both first and second world countries are decreasing at an alarming rate, but the trend is starting to occur in some third world countries as well. This together with the fact, that people all around the world live longer lives thanks to the progress in technology, medicine etc. causes that the population is getting older and therefore fewer people will be able to contribute to the workforce. This problem can partly be resolved by increasing the minimal retirement age, however because of obvious reasons this is not a long-term solution. The consequences of this is that aging world is destined to grow more slowly unless the technology revolution triggers major growth in productivity i.e. to work smarter rather than harder.

4.2.1.2 Productivity

Despite the exponential growth in technological progress and investments in innovation, the global productivity over the past decade has remained sluggish (whether measured as total-factor productivity [TFP] or labor productivity). What was seen as an opportunity for an unprecedented economic growth turned into one of today´s greatest economic enigmas for which there is no satisfactory explanation. [32] But why is it so?

One primary argument is that we are actually producing and consuming more efficiently than our economic indicators suggest. Take for example a mobile app for hailing a taxi. The app increases efficiency of the service and hence productivity. But because it is essentially free, it

[32] SCHWAB 2016: 28-32

provides uncounted value at home and at work, which creates a discrepancy between the value delivered via a given service versus growth as measured in national statistics. Another argument is that the true productivity explosion is yet to be experienced, provided the new technologies will be applied efficiently in the fourth industrial revolution. There is some evidence that supports this claim such as that both businesses and governments still struggle with transforming their organizations, so that they fully realize the efficiencies that digital capabilities deliver. [33]

4.2.2 Employment

The second major economic impact of the fourth industrial revolution will be on employment. As with previous industrial revolutions, the fourth industrial revolution will inevitably cause people to lose their jobs. However, the same is also true about creating a potentially even greater number of new jobs and even creating some whole new working positions. Industry 4.0 will, with great possibility, have the biggest impact on employment, both negative and positive, than the previous industrial revolutions. It is due to the already mentioned depth and speed of the occurring changes and the complete transformation of the entire systems. There is a fundamental uncertainty about the extent to which automation will substitute for labor and how long it is going to take but there is also one thing clear. New technologies will change the nature of work across all industries and occupations. And while it has always been the case that technological innovations have destroyed some jobs, they have also created new ones in different fields. For example, in 19th century the employment in agriculture consisted of the majority of the workforce in practically every country around the world, but with each industrial revolution this number kept decreasing and today this accounts (in rich countries) for 2% on average. This dramatic downsizing however took place relatively smoothly, without any major disruption or critical unemployment. A research done by Carl Benedikt and Michael Osborne of the University of Oxford analyzed 702 different professions and rated them based on their susceptibility to automation. In Figure 2 the professions most prone to automation are rated, where a number close to the value of 1 indicates a very high chance of future automation and a number close to the value of 0 indicates practically no risk at all. This research´s conclusion is

[33] SCHWAB 2016: 32-34

that about 47% of total employment in US is at risk and also that the trend is toward greater polarization in the labor market. Employment will grow in high-income cognitive and creative jobs and low-income manual occupations, while the employment of middle-income routine and repetitive jobs will suffer a great recession. [34]

[34] SCHWAB 2016: 35-38

Figure 2: Examples of professions most and least prone to automation

Most Prone to Automation

Probability	Occupation
0.99	Telemarketers
0.99	Tax preparers
0.98	Insurance Appraisers, Auto Damage
0.98	Umpires, Referees, and Other Sports Officials
0.98	Legal Secretaries
0.97	Hosts and Hostesses, Restaurant, Lounge, and Coffee Shop
0.97	Real Estate Brokers
0.97	Farm Labor Contractors
0.96	Secretaries and Administrative Assistants, Except Legal, Medical & Executive
0.94	Couriers and Messengers

Least Prone to Automation

Probability	Occupation
0.0031	Mental Health and Substance Abuse Social Workers
0.0040	Choreographers
0.0042	Physicians and Surgeons
0.0043	Psychologists
0.0055	Human Resources Managers
0.0065	Computer Systems Analysts
0.0077	Anthropologists and Archaeologists
0.0100	Marine Engineers and Naval Architects
0.0130	Sales Managers
0.0150	Chief Executives

Source: Carl Benedikt Frey and Michael Osborne, University of Oxford, 2013

4.3 The impact on business

Aside from the already mentioned changes in employment, growth, manufacturing and technology, the fourth industrial revolution will also affect how businesses are organized, led and resourced. Today´s CEOs and senior business executives struggle with the velocity of disruption and the acceleration of innovation in their fields. This is due to the early phase of digitization that we are currently at. As was also already mentioned there is a huge uncertainty or even concern about how will Industry 4.0 really affect the world of economy and business as we know it. What steps should a business leader make to ensure that their company will not only survive but also improve in this new era? This question is currently impossible to answer with certainty, but perhaps even here one advice should be taken for granted. It will be the leader´s ability to continually learn, adapt and challenge his or her own views on the situation at hand that will distinguish the next generation of successful business leaders.

As Schwab states: *"the fourth industrial revolution has four main effects on business across industries:*

- *customer expectations are shifting*

- *products are being enhanced by data, which improves asset productivity*

- *new partnerships are being formed ad companies learn the importance of new forms of collaboration*

- *operating models are being transformed into new digital models."* [35]

[35] SCHWAB 2016: 50-53

4.3.1 Customer expectations

Today´s customer, whether as an individual or business, lives in the world of the “now”. This means that companies today are expected to have ever shorter response intervals in addressing their customers´ needs. Additionally, customers also more and more rely on the feature of ordering a service or a product remotely from wherever they are. No longer is a person required to go into a shopping center in order to buy food for the next week. With a few mouse clicks or even through a mobile app the groceries can now be delivered directly to their door. Another fine example of this is Spotify, which allows its users to play almost any song in the world via digital access. As most today´s companies claim to be customer-centric the process of gathering customer data, from lifestyle to behavioral are crucial to them, as the insight into customer needs and behaviors drive marketing and sales decisions. As the trend of digitization is ever-growing it also leads to more transparency, meaning more data in the supply chain and more data at the fingertips of consumers. A good example of this are the price-comparing websites that allow their users to compare prices, the quality of services, performance of the product etc. This feature makes it near impossible for today´s companies to shirk accountability for poor performance and therefore adds to the emphasis of the saying, that brand´s equity is a prize hard won and easily lost.

4.3.2 Data-Enhanced Products

Today some products are equipped with a sensor that enables their constant monitoring and proactive maintenance. The data gathered by the sensor are then used to maximizes their utilization. For example, on aircrafts the airline controls know before the pilot if an engine is developing a fault. The airline can then instruct the pilot on what to do and the maintenance crew on the airport can be prepared in advance. The sensor can also measure and predict the asset´s performance. The performance can be measured over time and the data provide insights on operational tolerances and provide the basis for outsourcing products that are not core or strategic to the needs of the business. [36]

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[36] SCHWAB 2016: 53-56

4.3.3 Collaborative Innovation

The report of World Economic Forum´s on *Fostering Innovation-Driven Entrepreneurship in Europe* implies, that for young firms in Europe is crucial collaboration with larger and well-established firms to access a variety of organizational and financial resources. And on the other hand, large firms can profit from different approaches, perspectives and risk outlooks of young firms. Collaborative innovation partnerships can exploit these complementary capabilities – the development of truly novel and potentially disruptive products and services of the young firms and the deep-rooted processes and value networks of the established firms. [37]

An example of such collaboration is a partnership between Siemens and Ayasdi. Siemens, being and industrial giant spends around $4 billion a year in research and development. This of course generates an incredible amount of data and that is where Ayasdi, an innovative machine-learning company, comes in. With this partnership Siemens gains insights from the extracted data by Ayasdi, while they gain an opportunity for validating their topological data analysis approach with real-world data, while expanding market presence.

However, such collaborations require significant investments from both parties to develop proper firm strategy, to search for appropriate partners or to establish communication channels. In his book, Klaus Schwab says this about collaborative innovation: "*Sometimes, such collaborations spawn entirely new business models such as city car-sharing schemes, which bring together businesses from multiple industries to provide an integrated customer experience. This is only as good as the weakest link in the partnership chain…The fourth industrial revolution forces companies to think about how offline and online worlds work together in practice.* "[38]

[37] WEF 2015
[38] SCHWAB 2016: 57

4.3.4 New Operating Models

All of the above-mentioned impacts will challenge companies to rethink their operating models. While during the third industrial revolution purely digital platforms first saw the light of the day, the hallmark of the fourth industrial revolution is the appearance of global platforms. As was mentioned earlier, the trend of not owning a physical product directly but rather paying for the delivery of the underlying service via a digital platform is ever growing. Combined with the need to be more customer-centric and to enhance products with data is one of the main reasons why companies shift their business strategies to a more platform-oriented one. This shift from selling products to delivering services is one of the direct consequences of Industry 4.0. The benefit for the economy is more transparent and sustainable models of exchanging value, however it also creates challenges in how we define ownership, how we engage with unlimited content and how we interact with the increasingly powerful platform that provide these services.

In additional to this customer-centric operating model, a number of other business and operating models try to capitalize on the impacts made by the fourth industrial revolution. Frugal business models use the opportunities afforded by the interaction of digital, physical and human realms to open up new forms of optimization. An example of this is Michelin, whose aim is to provide high-quality services at low cost. Data-powered business models use the customer data to provide valuable information about the behavior of the customers to the companies. There is also an increasing number of businesses aiming toward models concentrating on employing new technologies to make more efficient use of energy and material flows therefore having positive impact on the environment.

These transformations mean that business will need to invest in cyber- and data-security systems. The cyber-security market was worth \$75 billion in 2015, \$95 billion in 2017 and is expected to exceed the value of \$160 billion by 2024.

Also, the need to attract the right sort of human capital means that talent and culture will have to be rethought. Schwab describes this new concept of talentism as follows: *"In a world where talent is the dominant form of strategic advantage, the nature of organizational structures will have to be rethought. Flexible hierarchies, new ways of measuring and rewarding performance, new strategies for attracting and retaining skilled talent will all become key to organizational* *success…Motivation will we increasingly intrinsic, driven by the collaborative desire of employees and management for mastery, independence and meaning."* This will lead to businesses being increasingly focused on distributed teams, remote workers and dynamic collectives, that will exchange insights and data about the tasks they work on.[39]

5 How are companies preparing for the upcoming Industry 4.0

This part of the thesis deals with outlining the method of gathering data from the companies and also about the evaluation of the data.

5.1 Methodology

The data were acquired via an online questionnaire. The questionnaire consisted of 13 questions. My focus was on Czech production companies and for that reason the questions in the questionnaire were accordingly composed for them. The reason, why I decided to focus on production companies is that service and other companies in Czech Republic are still barely even recognizing the change that is taking place in modern business. From historical point of view the pattern stays the same. Just like during the second industrial revolution, when mass production was first taking roots in big production companies like Ford, the fourth industrial revolution does the same. More and more are such companies being aware of this fact, and so they are taking steps in ensuring that their position on the market gains an edge or at least stays the same and will not be rolled over by the competition that is also focused on innovation.

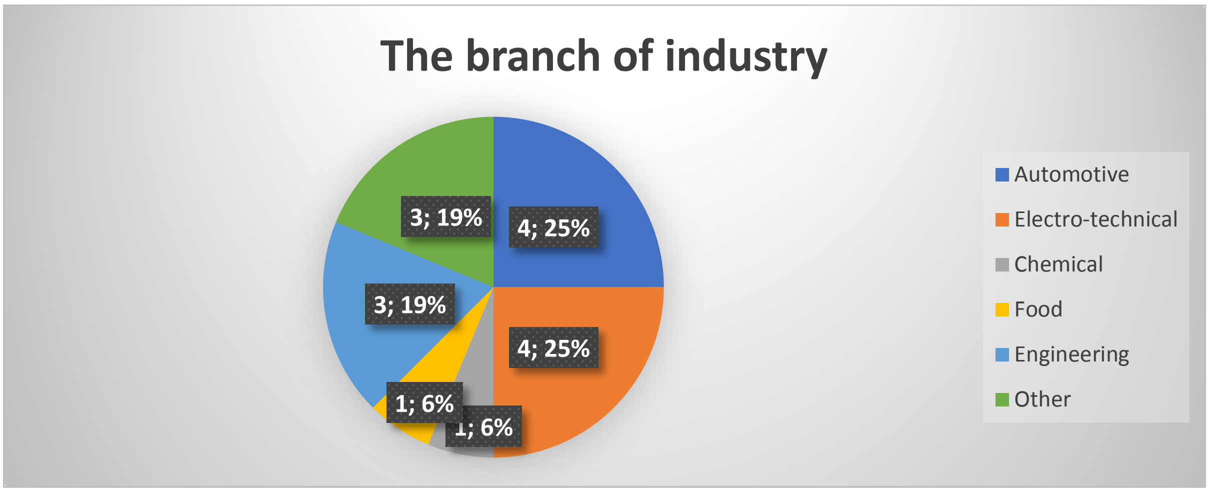
5.2 Questionnaire

5.2.1 The branch of industry

The first question deals with the type of industry that the respondents work at. The option other represents two less traditional industries – one is producing wooden covers and the other produces compressed air.

[39] SCHWAB 2016: 57-61

Figure 3: The branch of industry

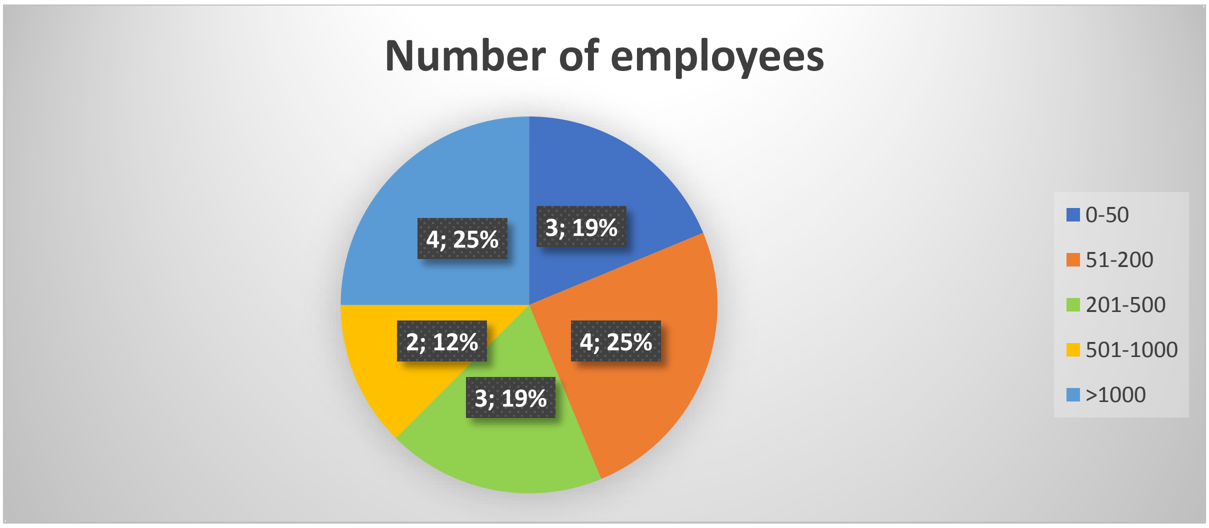


Source: own representation

5.2.2 Number of employees

The second question dealt with the number of employees each company employs. I was expecting that companies with larger number of employees will be the pioneers of implementing Industry 4.0 into their business, however, this was proven not to always be the case.

Figure 4: Number of employees

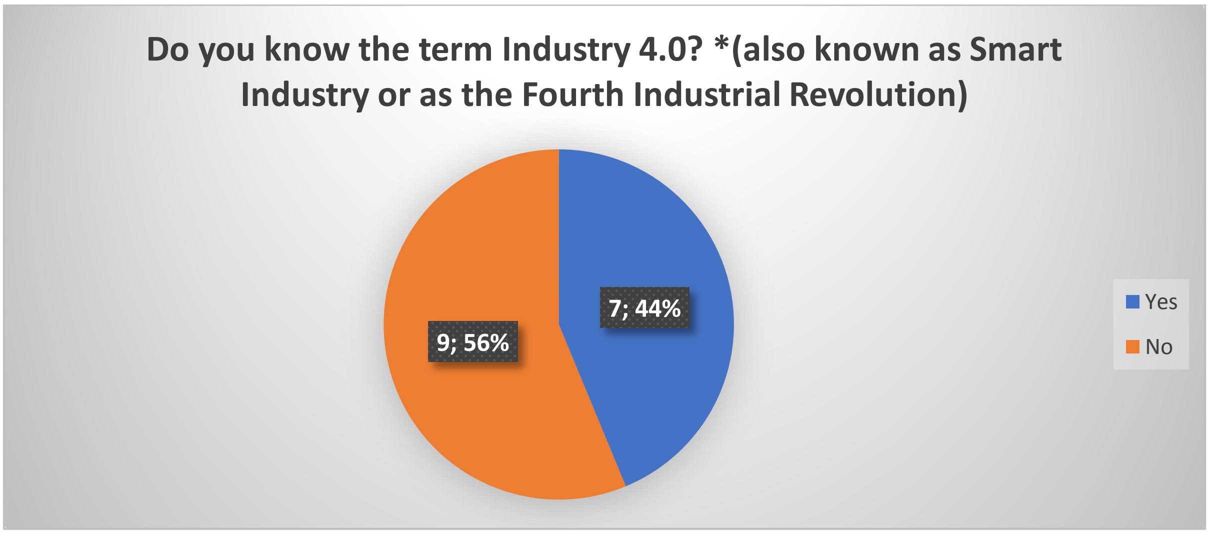


Source: own representation

5.2.3 Familiarity with the term Industry 4.0

The third question if companies know the term Industry 4.0 turned out an interesting result. More than 50% of the respondents did not actually heard about this term before. However, as the next questions will show, even the companies that chose no as an answer in at least some way prepare for the upcoming changes that the fourth industrial revolution.

Figure 5: Do you know the term Industry 4.0?

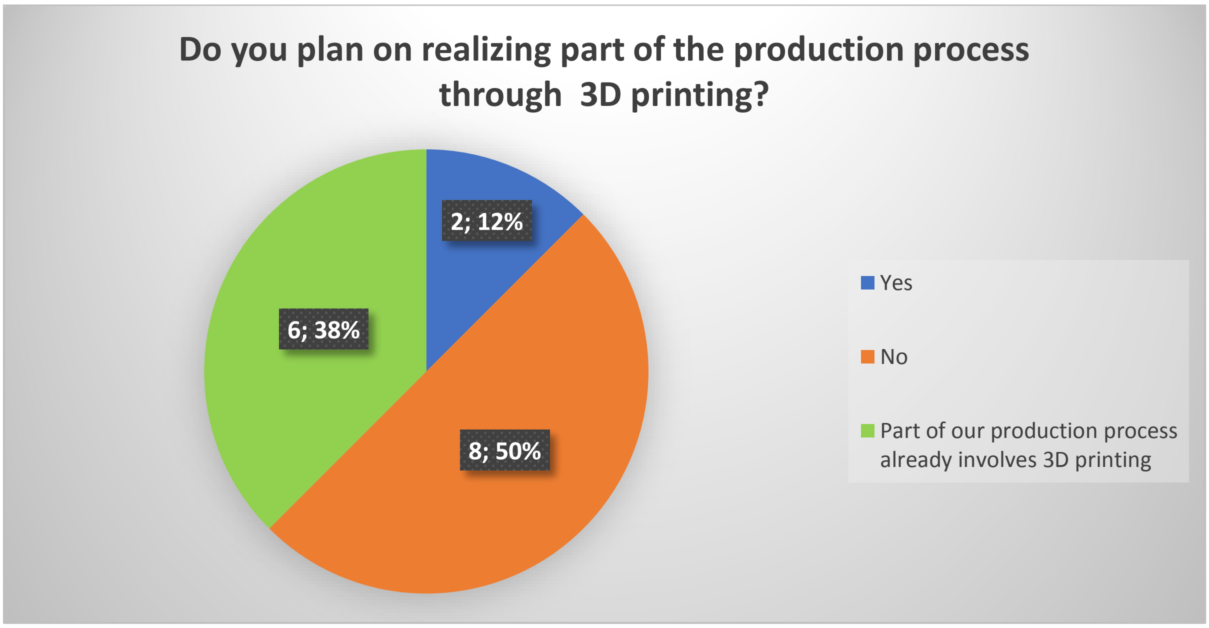


Source: own representation

5.2.4 The use of 3D printing

Question number four asks if companies realize or plan to realize that part of the production process will be done through 3D printing. Here the results were 50% yes and 50% no. What is interesting is that all companies dealing with automobiles answered that part of their production process already involves 3D printing. This confirms the previously mentioned information about the possibility of 3D printing reducing costs of production and increasing production speed in this field.

Figure 6: Do you plan on realizing part of the production process through 3D printing?

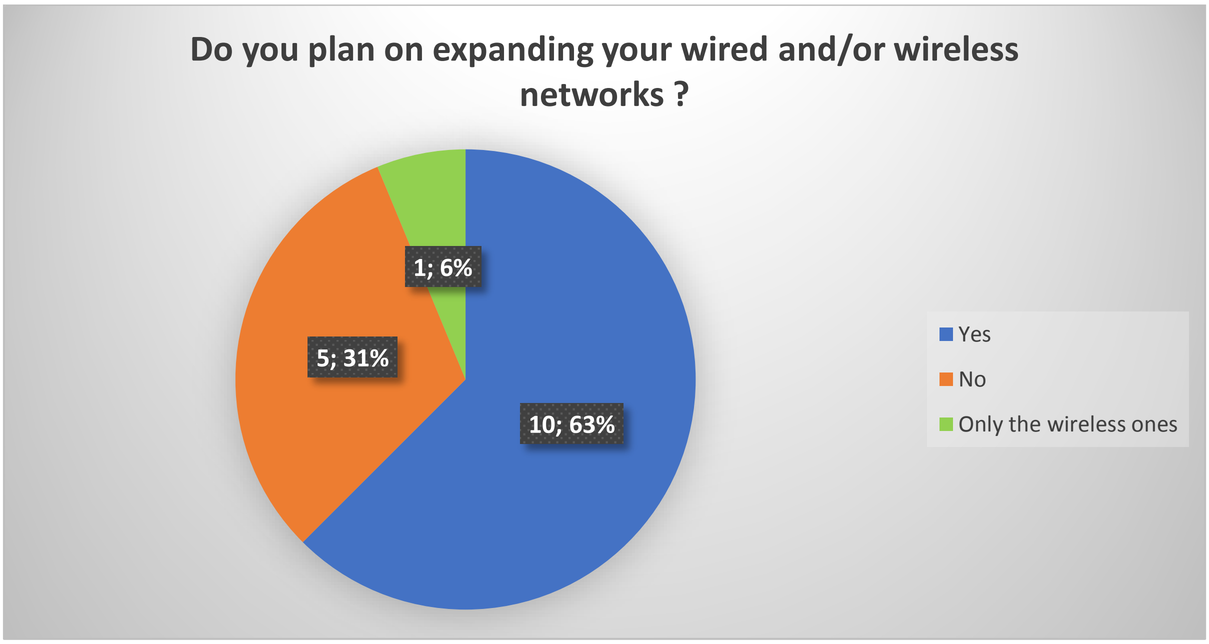


Source: own representation

5.2.5 Expansion of networks

The next question dealt with expansion of wired and wireless networks. As it is necessary for the factory of the future to have developed networks within its structure, I consider this question to be one of the most important of the whole questionnaire. The results show that about 2/3 of the respondents do not underestimate the importance of developing their networks while the rest either believes their networks are developed enough or do not consider this to be an issue at all. I believe that for a successful implementation of things like IoT into the company network, the whole infrastructure will have to keep up with the newest network protocols and other features, for an example the already mentioned IPv6.

Figure 7: Do you plan on expanding your wired and/or wireless networks?

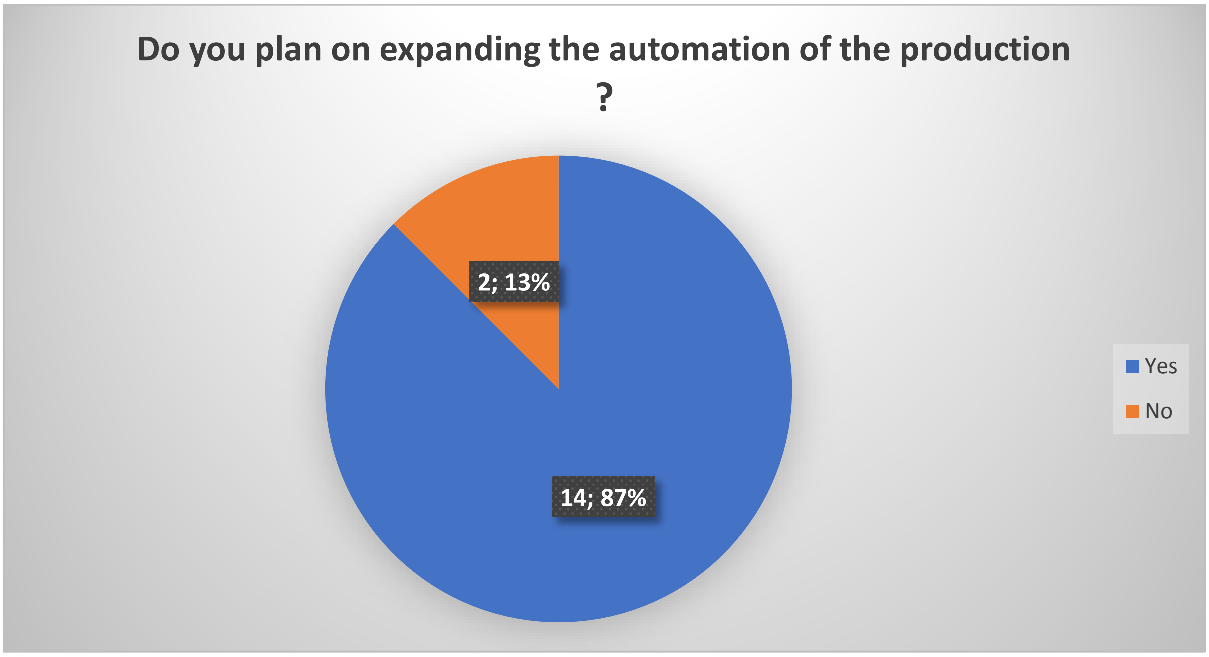


Source: own representation

5.2.6 Expansion of automation in the production

Another very important question that deals with automation in the production. Nearly all respondent companies answered here that they do plan to expand the automation of the production, meaning more machines and mechanized processes will participate in the production process, which will result in faster and more precise production and will also expand the company´s portfolio. There is however also a reason for concern because of replacing employees with machines.

Figure 8: Do you plan on expanding the automation of the production?

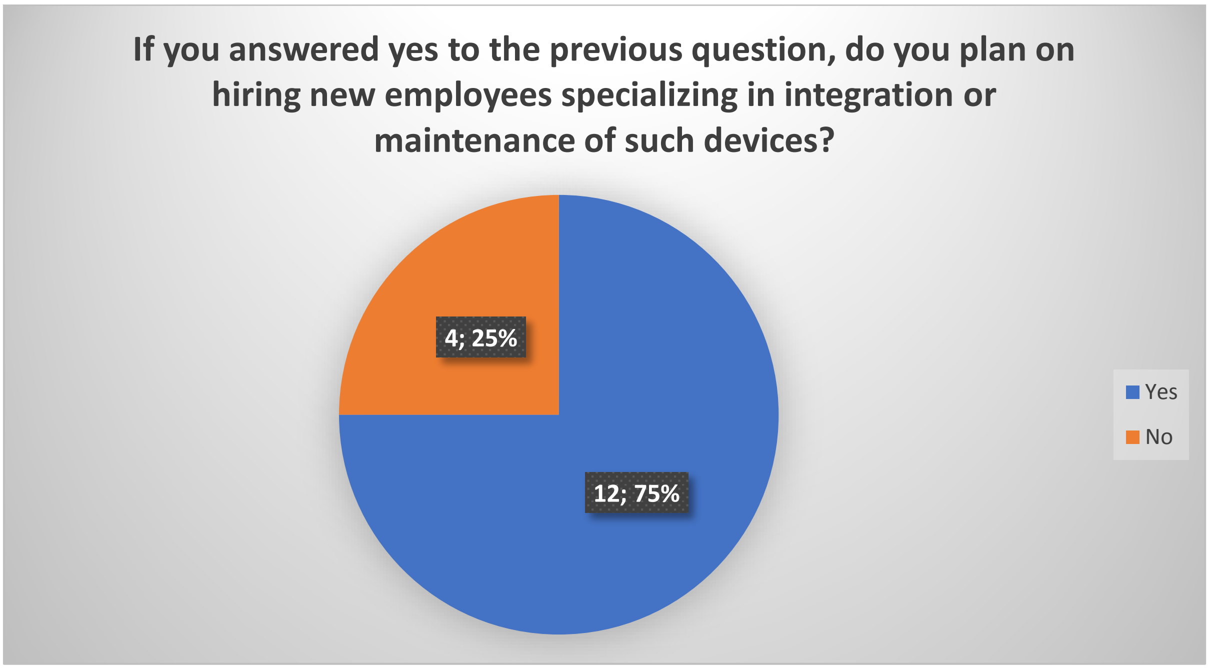


Source: own representation

5.2.7 Hiring new employees for maintenance of machines

The problem of replacing human workforce with machines can be at least partly combated with hiring new employees that will maintain such machines. 3/4 of respondents answered that they indeed do plan on hiring new employees for machine maintenance.

Figure 9: Do you plan on hiring new employees for maintenance?



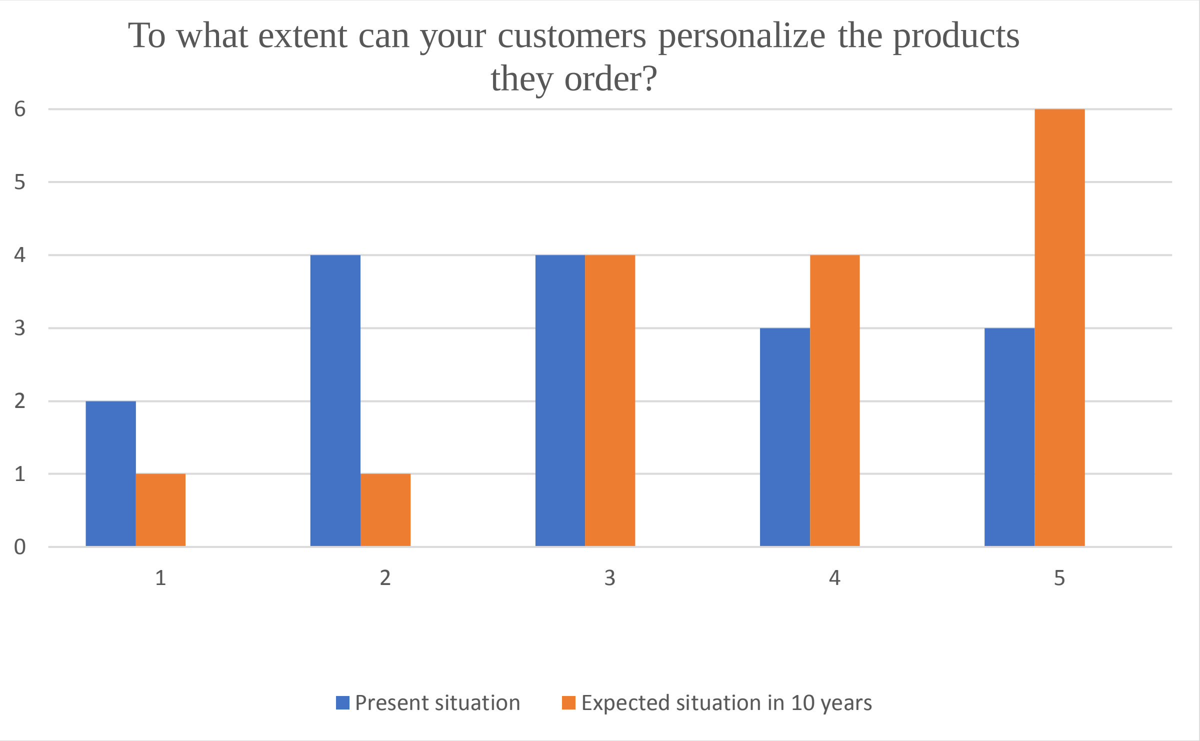
Source: own representation

5.2.8 Product customization

The following questions of this type differ from the previous questions in that, that the first column (blue) shows the current situation in the company, while the second column (orange) shows how the company expect the situation to be in 5-10 years. The numbers at the bottom represent the situation, where 1 is the lowest value and 5 the highest. The numbers to the left then indicate how many respondents chose this option.

Product personalization is one of the hallmarks of Industry 4.0. As today companies are becoming more and more focused on the needs of the customer, the emphasis on product personalization is growing and is expected to keep doing so. And the companies are well aware of that. As can be seen from the chart below, most companies already allow for some level of product customization and nearly all also expect the trend to either keep growing or to at least stay the same. Value 1 here means the products allow for no customization at all - (standard mass production). The value 5 means that customer can fully customize the product.

Figure 10: To what extent can your customers personalize the products they order?

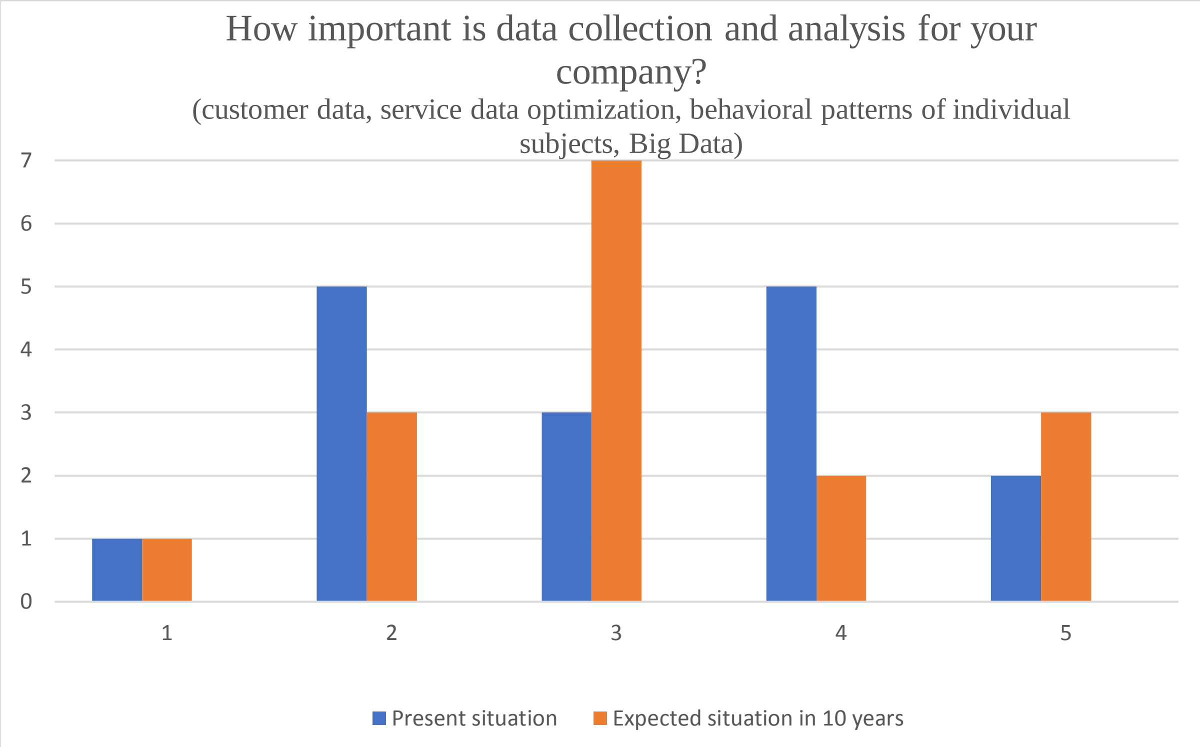


Source: own representation

5.2.9 Importance of data collection

As with product customization, the companies over the years realize the importance of collecting data and its analysis. And while many companies do not consider data analysis to be one of the main indicators for their company, most acknowledge them as an important resource for their business strategy. Lowest value means the data analysis is not significant - no data analysis is used in the business model, while the maximum value means it is essential for the company - data is one of the most important indicators for this company.

Figure 11: How important is data collection and analysis for your company?

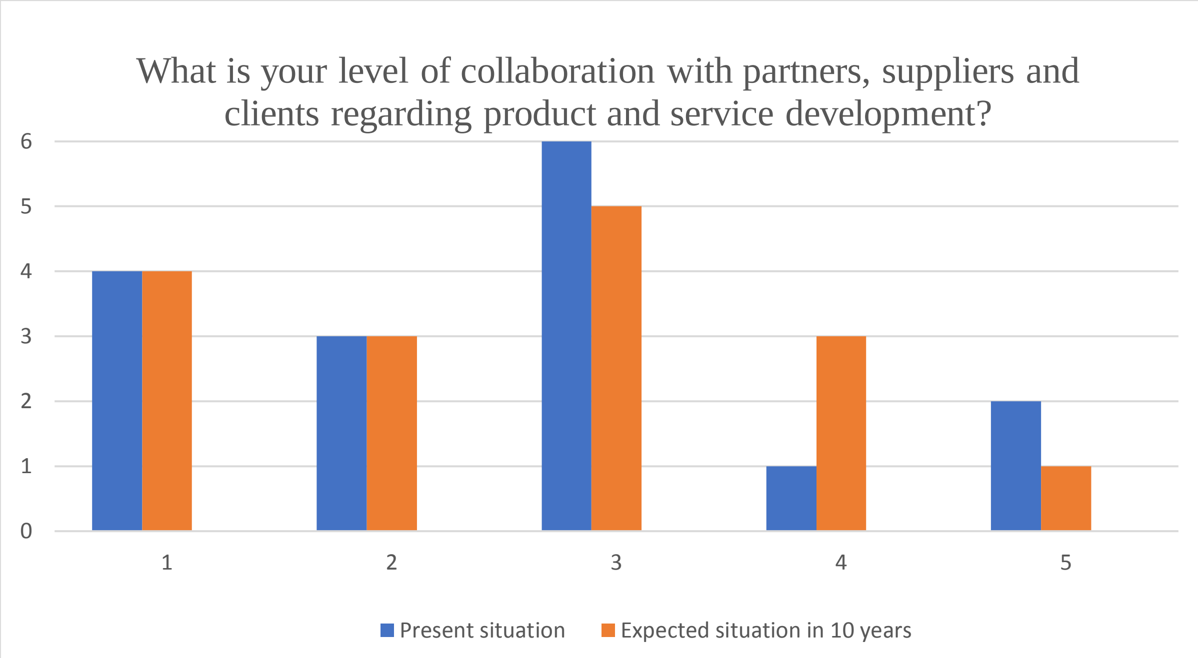


Source: own representation

5.2.10 Level of collaboration with partners and clients

The involvement of customers in new product development is considered as a successful strategy and tactic to improve new product success. In very early times, customers were strongly involved in the development of a new product, if they had the power or means to do so. Modern production technologies, supported by modern communication technologies, support similar behavior. However, as seen from the chart below, the companies are rather reserved regarding this approach. Lowest value means that product development is done completely without the need to exchange information with partners, suppliers or customers, while the maximum value means intensive collaboration with these parties.

Figure 12: What is your level of collaboration with partners and clients regarding product and service development?

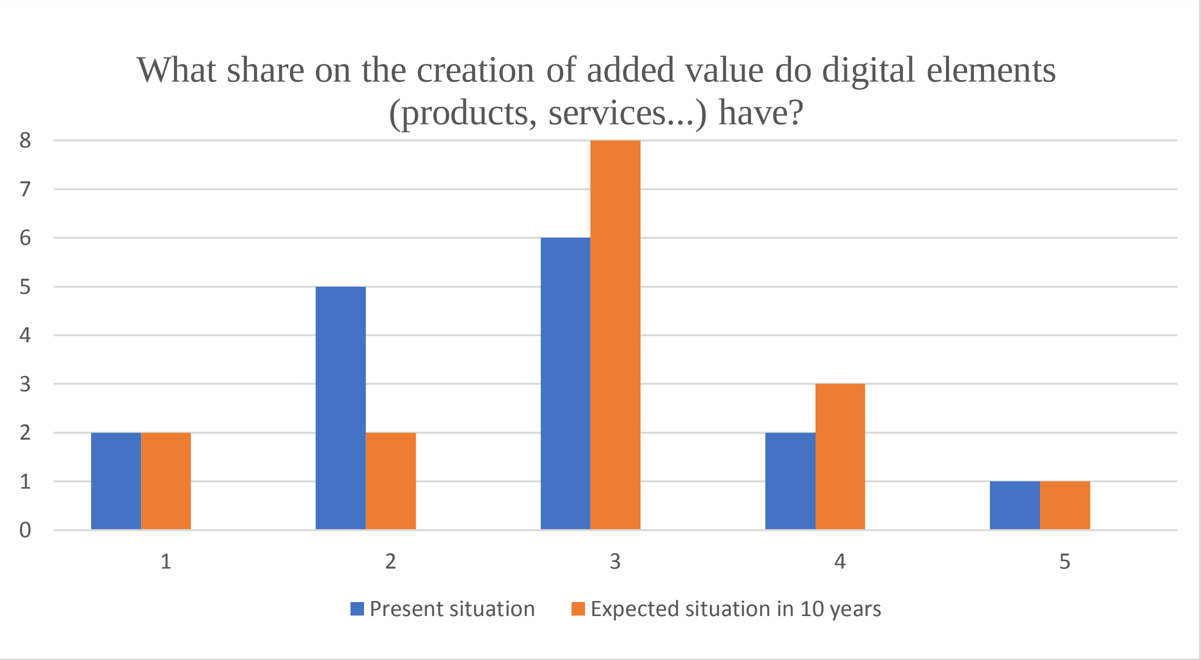


Source: own representation

5.2.11 Share of digital products on added value

Here the lowest value means, that the value is generated solely by the sale of physical products or services related to products, while the maximum value means that digital products make up the main share - Value is primarily made up of pure digital products and licensing of intellectual property (e.g., license for 3D product printing). The results show that digital products already are important part in the creation of added value today and the companies expect this will grow in the future although only by moderate amount.

Figure 12: What share on the creation of added value do digital elements have?

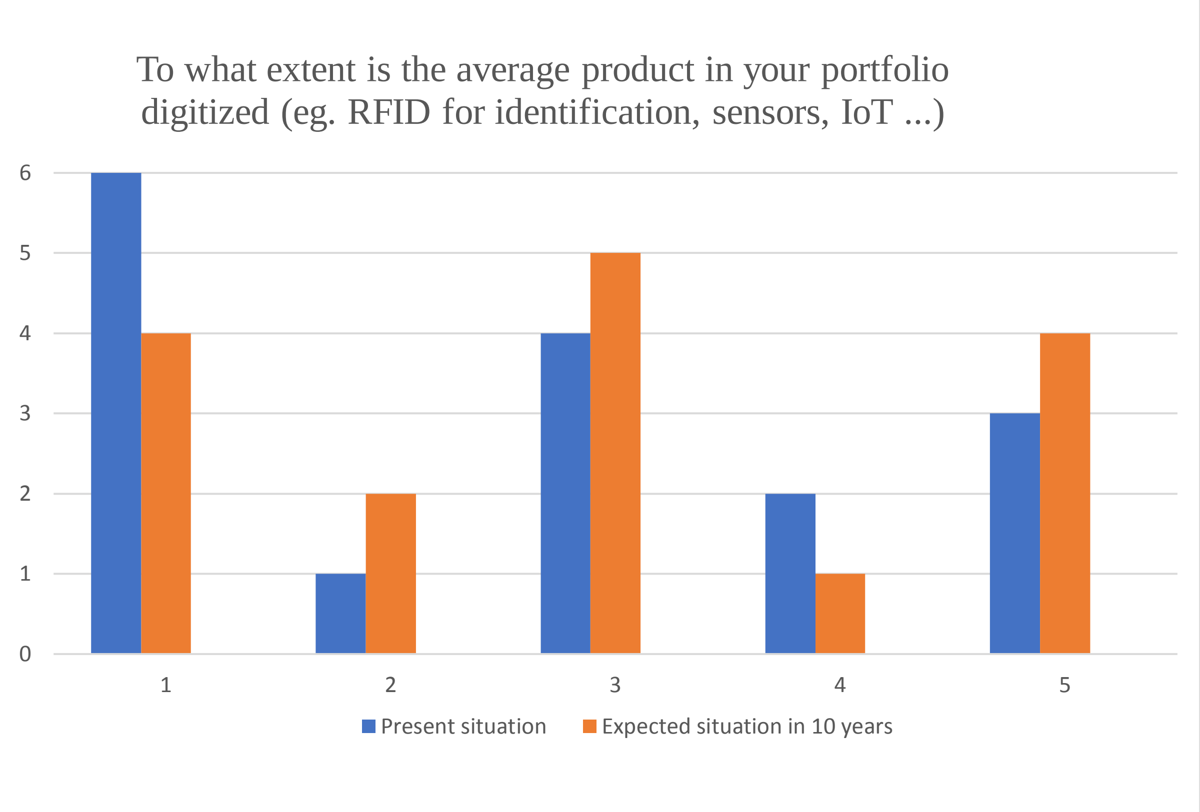


Source: own representation

5.2.12 Digitization of products

As was already mentioned, with the ever-increasing demand by customers on quality and availability of services, most companies will not be able to retain or improve their position on the market without incorporating digital products and features into their portfolio. Here the progress seems to be relatively slow, however the trend in the world shows us that the process of digitization of products will keep on growing, so it is safe to assume, that the same will eventually happen with Czech companies as well. Here the value 1 means not at all – The portfolio is focused on purely physical products (e.g. Mechanical machines without digital features or network connections, etc.) and the maximum value indicates that digital services are at the core of the portfolio; physical products are primarily used as a medium (e.g. Appstore for additional functions).

Figure 13: To what extent is the average product in your portfolio digitized?

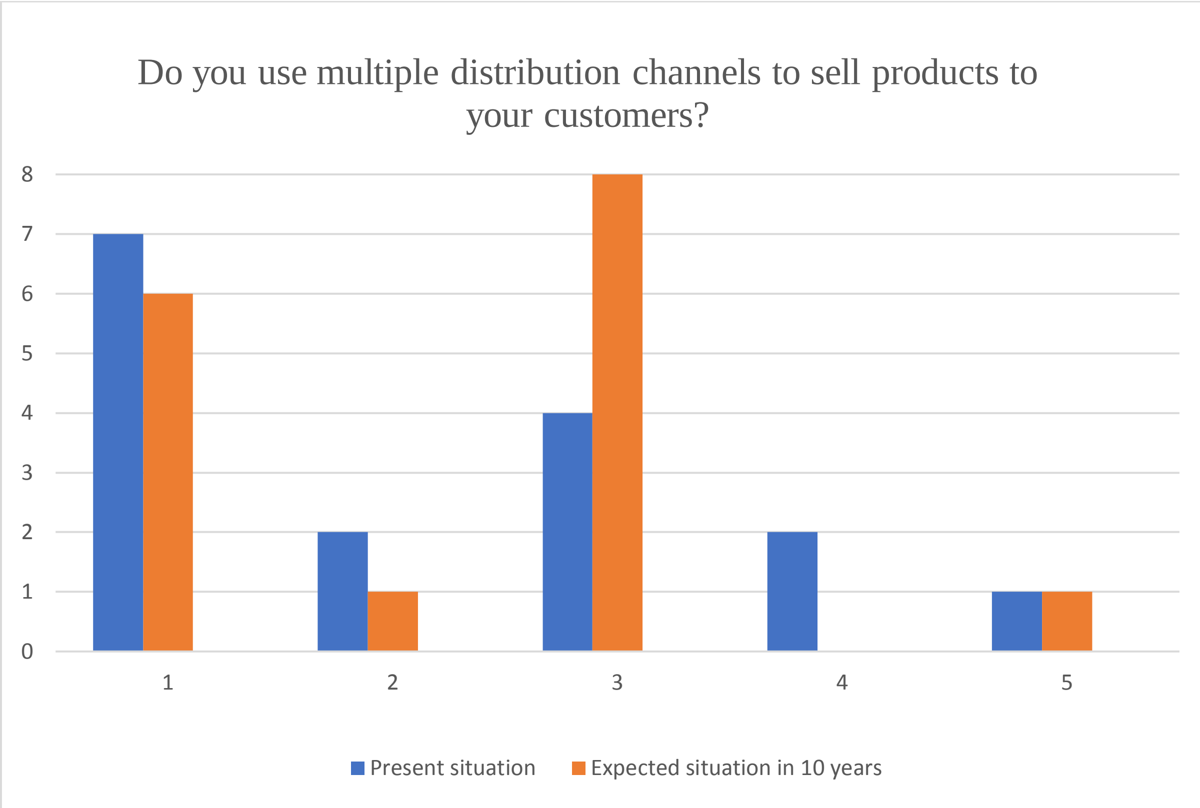


Source: own representation

5.2.13 The use of multiple channels for sales

As with the previous question the Czech companies seem to be rather skeptical about using multiple channels for sale. However, as with the previous example the global business seems to indicate that the use of multiple channels will only keep on growing. Value 1 represents here the Business - customer model (sales without intermediates). Value 5 means the company uses multi-channel model - integration of several physical and digital dist. channels (e-shop, retail, wholesale, agent)

Figure 14: Do you use multiple distribution channels to sell products to your customers?



Source: own representation

Conclusion

The primary objective of this thesis was to analyze the data gathered from Czech companies that are adjusting or are presumed to soon be adjusting to the changes that the fourth industrial revolution will bring. My assumption before the survey was that only the biggest production companies will actually have any awareness about this topic but that was proven not to be the case as even some companies with relatively small number of employees are starting to take notice and implement changes to their business model.

The results also showed that the companies consider some areas to be of great importance to them such as digitization or the need to hire new employees that will maintain them. On the other hand, are the companies in some areas rather reserved such as with product digitization or with using multiple distribution channels for sale.

The reason for this could simply be that the companies in the Czech Republic or the business world in general is not very well informed about this to be ready to make such radical changes in some areas. When I asked my family, friends and acquaintances if they know, what the term Industry 4.0 means, the general answer was “I do not know” only few who are really familiar with the business sphere were somewhat able to describe what it encompasses, although no one knew a clear definition. I believe that it is the same in the business world. The leaders of companies but also country leaders should get familiar with this topic as it has the potential to boost Czech economy into heights it has not seen before. I am convinced that if Czech companies and the Czech economy as a whole wants to compete with world´s top then the implementation of Industry 4.0 standards within a short period of time will be necessary. The Ministry of Industry and Trade of the Czech Republic has published in 2017 a document over 200 pages long called Initiative of Industry 4.0 where features of Industry 4.0 and its implementation is described in detail, which I consider to be a great step forward. However, how fast the implementation of it will be depends mainly on the awareness of politicians and individual companies.

Czech Resumé

Tato práce se zabývá popisem průmyslu 4.0 a o jeho dopadech na obchodní sféru. Průmysl 4.0 je pojem, se kterým se firmy ale i zákazníci po celém světě budou stále více setkávat. Průmysl 4.0 umožňuje rychlejší, levnější a preciznější výrobu produktů. Toho se dosahuje díky stále se rozvíjející digitalizací všech služeb a výrobních procesů. Právě digitalizace je hlavním znakem průmyslu 4.0. Ať už se jedná o Internet věcí, analýzu Velkých Dat nebo I prostou komunikaci se zákazníkem, firmy po celém světě budou nuceny na tento trend digitalizace stále více přistupovat a zavádět nové technologie, pokud si chtějí udržet své postavení na trhu. Dále se tato práce zabývá zkoumáním toho, jak jsou české výrobní firmy připravené na příchod průmyslu 4.0. Toho bylo dosaženo pomocí dotazníku, jehož výsledky ukazují, že většina českých výrobních firem má určité povědomí o změnách, které průmysl 4.0 přináší. Pozitivním zjištěním bylo také to, že české výrobní firmy se připravují a v některých případech již i zavádí některé klíčové technologie, které průmysl 4.0 zahrnuje.

English Resumé

This thesis deals with the description of Industry 4.0 and its impact on business. Industry 4.0 is a concept that businesses and customers around the world will increasingly encounter. Industry 4.0 enables faster, cheaper and more precise product manufacturing. This is achieved through the ever-increasing digitization of all services and production processes. And it is digitization that is the main hallmark of Industry 4.0. Whether it is the Internet of Things, Big Data analysis or even simple customer communication, businesses around the world will see this trend of digitization more and more and they will have to incorporate these new technologies if they want to maintain their market position. In addition, this thesis examines how are the Czech manufacturing companies ready for the upcoming Industry 4.0. This was achieved with a questionnaire, the results of which show that most Czech manufacturing companies are aware of the changes that industry 4.0 is bringing. It was also a positive finding that Czech manufacturing companies are preparing and, in some cases, already incorporating some of the key technologies that industry 4.0 includes.

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List of charts

Appendices

Figure 1: Tipping Points expected to occur by 2025

Table: Tipping Points Expected to Occur by 2025

	%
10% of people wearing clothes connected to the internet	**91.2**
90% of people having unlimited and free (advertising-supported) storage	**91.0**
1 trillion sensors connected to the internet	**89.2**
The first robotic pharmacist in the US	**86.5**
10% of reading glasses connected to the internet	**85.5**
80% of people with a digital presence on the internet	**84.4**
The first 3D-printed car in production	**84.1**
The first government to replace its census with big-data sources	**82.9**
The first implantable mobile phone available commercially	**81.7**
5% of consumer products printed in 3D	**81.1**
90% of the population using smartphones	**80.7**
90% of the population with regular access to the internet	**78.8**
Driverless cars equalling 10% of all cars on US roads	**78.2**
The first transplant of a 3D-printed liver	**76.4**
30% of corporate audits performed by AI	**75.4**
Tax collected for the first time by a government via a blockchain	**73.1**
Over 50% of internet traffic to homes for appliances and devices	**69.9**
Globally more trips/journeys via car sharing than in private cars	**67.2**
The first city with more than 50,000 people and no traffic lights	**63.7**
10% of global gross domestic product stored on blockchain technology	**57.9**
The first AI machine on a corporate board of directors	**45.2**

Source: *Deep Shift – Technology Tipping Points and Societal Impact*, Global Agenda Council on the Future of Software and Society, World Economic Forum, September 2015

Figure 2: Examples of professions most and least prone to automation

Most Prone to Automation

Probability	Occupation
0.99	Telemarketers
0.99	Tax preparers
0.98	Insurance Appraisers, Auto Damage
0.98	Umpires, Referees, and Other Sports Officials
0.98	Legal Secretaries
0.97	Hosts and Hostesses, Restaurant, Lounge, and Coffee Shop
0.97	Real Estate Brokers
0.97	Farm Labor Contractors
0.96	Secretaries and Administrative Assistants, Except Legal, Medical & Executive
0.94	Couriers and Messengers

Least Prone to Automation

Probability	Occupation
0.0031	Mental Health and Substance Abuse Social Workers
0.0040	Choreographers
0.0042	Physicians and Surgeons
0.0043	Psychologists
0.0055	Human Resources Managers
0.0065	Computer Systems Analysts
0.0077	Anthropologists and Archaeologists
0.0100	Marine Engineers and Naval Architects
0.0130	Sales Managers
0.0150	Chief Executives

Source: Carl Benedikt Frey and Michael Osborne, University of Oxford, 2013