UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER' S THESIS

AN ANALYSIS OF INDUSTRY 4.0 TECHNOLOGIES CONTRIBUTIONS AT SELECTED SLOVENIAN COMPANIES

Ljubljana, October 2020

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The undersigned Rok Primožič, a student at the University of Ljubljana, School of Economics and Business, (hereafter: SEB LU), author of this written final work of studies with the title An analysis of Industry 4.0 technologies contributions at selected Slovenian companies, prepared under supervision of Associate Professor Matej Černe, PhD.

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LIST OF ABBREVIATIONS

AHK – German-Slovenian Chamber of Industry and Commerce

AI – Artificial Intelligence

AR – Augmented Reality

CEO – Chief Executive Officer

CIM – Computer Integrated Manufacturing

CPS – Computer Processing System

CRO – Chief Robotics Officer

ESIF – European Structural and Investment Funds

EU – European Union

GDP – Gross Domestic Product

GPU – Graphical Processing Unit

GVA – Gross Value Added

HR – Human Resources

ICT – Information and Communication Technologies

IoT – Internet of Things

IT – Information Technology

KPI – Key Performance Indicator

OEE – Overall Equipment Effectiveness

OEM – Original Equipment Manufacturer

PLC – Programmable Logic Controller

PPP – Public-Private Partnership

R&D – Research and Development

RFID – Radio-Frequency Identification

ROI – Return on Investment

SME – Small and Medium sized Enterprises

TPS – Toyota Production System

UID – Unique Identifier

VR – Virtual Reality

INTRODUCTION

Since the first Industrial Revolution in 1775 we have come far in the fields of technology and automation. Currently we are in the phase of the fourth Industrial Revolution also called Industry 4.0 (Sentryo, 2017).

It all started with the mechanization of manufacturing in the first Industrial Revolution, where water and steam were used to generate power. Sometime after in 1879, Thomas Edison invented the electric light bulb, later people tried to use electricity in manufacturing as well. The so-called second Industrial Revolution started with mass production assembly lines using electric powers in 1870. The next big shift occurred after the Second World War in 1969 where the era of programmable logic controllers and robots began. The upgrade that is happening now is merely the optimization of the machines with artificial intelligence, machine learning and super-fast connection between the devices (Sentryo, 2017; Simio, 2017).

Table 1: Comparison of Industrial Revolutions

	Time Periods	Technologies and capabilities
First	1784-mid 19th century	Water-and steam-powered mechanical manufacturing
Second	Late 19th century – 1970s	Electric-powered mass production based on the division of labor (assembly line)
Third	1970s - Today	Electronics and information technology drive new levels of automation of complex tasks
Fourth	Today -	Sensor technology, interconnectivity and data analysis allow mass customization, integration of value chains and greater efficiency

Source: European Union (2015)

Industry 4.0 is a broad term, with many different interpretations by various authors. The most common interpretation of the term, however, refers to new technologies, digitalization, and robotization (Maresova et al., 2018).

In Industry 4.0 we use computers which were introduced in Industry 3.0. We want to have as high connectivity as possible and established communication with one another to make decisions without human involvement. The combination of a cyber-physical system, the Internet of Things and the Internet of System are key components that enable Industry 4.0 and make the Smart Factory possible (Marr, 2018).

Industry 4.0 makes full use of emerging technologies combined with the rapid development of machines and tools to tackle the global challenges and improve industry levels. It focuses heavily on interconnectivity, automation, machine learning, and real-time data. The main concept of Industry 4.0 is to utilize the advanced information technology to deploy IoT services (Tay, Lee, Hamid & Ahmad 2018).

Production can run faster and smoothly with minimum downtime by integrating engineering knowledge, giving us access to real-time insights across processes, partners, products, and people. Therefore, the products built are of better quality, production systems are more efficient, easier to maintain, achieving cost savings, which are nowadays more and more important (Tan & Wang, 2010).

The benefits that Industry 4.0 brings along are the main reason for implementation. It helps manufacturers with current challenges by allowing them to be more flexible and more adaptable to changes in the market. It can also contribute to the increase in the speed of innovation with the main focus on the consumer, leading to faster design processes. Workers in the current Industrial Revolution have the role of production coordinators, which results in an improved work-life balance of employees (Immerman, 2017).

Throughout the thesis, we will discuss the technologies that are usually a part of the 4th Industrial Revolution and the added value that the technologies bring. Our main focus will be put on the analysis of three Slovenian companies, in particular how they are handling the industrial changes. In the end we will try to come up with some recommendations how they can improve and optimize their operating processes.

The **purpose** of the thesis is to suggest the companies how to cope with the rapid changes in the industrial world since digitalization and different technologies are changing the current way companies work.

The **goal** of the master thesis is to analyze three Slovene companies and see how they are facing the industrial changes of Industry 4.0 by reviewing literature based on this topic and conducting interviews with company employees.

Throughout the thesis we will try to answer the following research questions:

- What Industry 4.0 technologies did the companies implement and why?
- Did the companies have any challenges implementing new technologies?
- How does the new Industrial Revolution impact the HR sector?

With the help of already existing literature and methods of synthesis and comparison, we will try theoretically to closely describe what stands under the name of Industry 4.0 and which components need to be included to be presented as 4.0. We will suggest how specific companies can benefit from Industry 4.0.

Our research method will consist of case studies, interviews, analyzing of text answers, analyzing text data reduction, obtaining second-order categories and codes, and finally interpreting the results. The research will be based on the exploratory method of induction since there are not many deductive empirical studies to derive from.

First, we will review the existing literature about Industry 4.0 and the status of it in Slovenia, focusing on three major companies. A fluid control equipment company A, a pharmaceutical company B and company C which is in the automotive industry.

Secondly, in the first part, we will review how new technologies can affect the company in terms of added value, innovation, employment and employees' responses. To get more in-depth knowledge, we will interview employees from two fields of employment (Human Resource employees and Technical/Management employees) to get more insight into Industry 4.0.

1 INDUSTRY 4.0

We are currently in the era of the fourth Industrial Revolution, where computers that were introduced in the previous revolution received their own brain that enables them to communicate with each other and learn. Such changes will allow companies to make processes more efficient and reduce costs, with machines capable of analyzing changes and predicting mistakes with the help of artificial intelligence. The productivity is drastically going to increase, and employees will have to adapt to those rapid changes by learning new skills, since many assembly workers might be replaced by machines (Lorenz et al., 2015).

So far, major countries like Germany, France, the USA, Japan and China made huge implementations of Industry 4.0. German government launched Industry 4.0 as one of the 10 "Future Projects" as part of their high-tech strategy in 2013. Their aim is to create smart factories and manufacturing innovation centers all over the country. France, in the same year also launched 34 new industrial projects. With projects such as next-generation high-speed trains, electric aircraft, autonomous cars, smart textile, factories of the future, battery power, embedded software and systems, satellite electric propulsion, green chemistry and biofuels, cloud computing, nano-electronics, they are among the top Industry 4.0 countries. The USA launched in 2016 the National Network for Manufacturing Innovation. This initiative is expected to result in 45 innovation centers throughout the country to develop smart manufacturing technologies. Some of the areas of focus include additive manufacturing, manufacturing of lightweight materials and developing integrated photonics. Japan in 2016 launched Society 5.0. This societal transformation plan focuses on developing solutions in the areas of IoT, artificial intelligence, cyber-physical systems, additive manufacturing, new energy vehicles, robots, virtual and augmented reality and data analytics. And lastly China aims to create 15 manufacturing innovation centers by 2020 and 40 by 2025. The areas of focus include automated machine tools & robotics, new advanced information technology, aerospace and aeronautical equipment, maritime equipment and high-tech shipping, modern rail transport equipment, new-energy vehicles and equipment, power equipment, agricultural equipment, new materials and biopharma and advanced medical products. The plan is called Made in China 2025 (Mehta & Hamke, 2019).

1.1 Common technologies that form industry 4.0

Autonomous robots, simulations, system integration (horizontal & vertical), Internet of things, cybersecurity, cloud services, additive manufacturing, augmented reality and big data analytics are some of the main technologies that are emerging right now. Those technologies will make smart homes, smart cities and smart factories a reality (Lorenz et al., 2015). All above-mentioned technologies can be summarized into four major components defining the term “Industry 4.0” – cyber-physical systems, IoT, Cloud computing and cognitive computing.

Artificial Intelligence

Artificial intelligence or intelligence of machines is intelligence demonstrated by machines. When a device can perceive the environment and take actions to achieve certain goals, it is using artificial intelligence. Like Data Robot CEO Jeremy Achin described AI: "AI is a computer system able to perform tasks that ordinarily require human intelligence. Many of these artificial intelligence systems are powered by machine learning, some of them are powered by deep learning, and some of them are powered by very boring things like rules." (Builtin, 2017)

Artificial intelligence development is generally divided into four sub-categories:

- Reactive machines,
- limited memory,
- theory of mind,
- self-awareness.

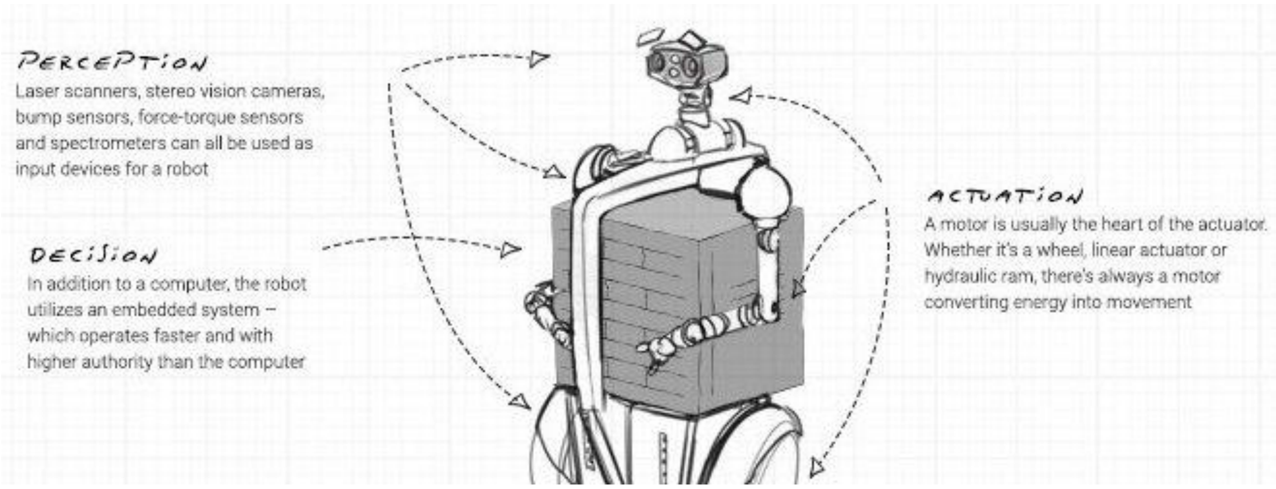
Reactive machines are the most basic AI systems, which do not have the ability to form memories or to use past experiences to inform current decisions. The second category - AI machines or Limited memory category has the ability to investigate the past. Machines in this category can identify specific objects, monitoring them over time. Third classification – theory of mind is more future related. If AI systems are indeed ever to walk among us, they will have to be able to understand that each of us has their own thoughts and feelings. The final classification of AI development is to build the system that can form representation about themselves (Hintze, 2016).

All those development stages drive technology to the edge. Nowadays, devices with AI can mimic human functions such as learning and problem-solving. AI is relevant to any intellectual task, and it can be used almost in any industry. Currently, it is present in healthcare, military, automotive, economy and similar. It is also used to solve most difficult problems in computer science with methods such as logic, evaluating progress, artificial neural networks and search and optimization. With the widespread use of AI, we could have unwanted and dangerous consequences. To reduce the chances of AI abuse, some regulations have been established (Stuart & Norvig, 2020).

Autonomous robots

Autonomous robots are robots which perform behaviors or tasks with a high degree of autonomy. They can make their own decisions and then perform an action. A true autonomous robot is one that can perceive its environment, make decisions on what it perceives and then actuate a movement or manipulation within that environment. Autonomous robots can work for an extended period without human intervention. Crucial key components (Figure 1) for autonomous robots are perception, decision, actuation. New generations of autonomous robots will be able to communicate with each other through sensors and wireless networks. With the help of AI, they will be able to learn, first from humans and later from their own work/errors with advanced AI (Walker, 2018).

Figure 1: Crucial key components of Autonomous robots



Source: Walker (2018)

Such robots are desirable in fields such as spaceflight, household maintenance, wastewater treatment and similar. A fully autonomous robot can gain information about the environment, work for an extended period without human intervention, move either all or part of itself throughout its operating environment and lastly they can avoid situations which are harmful to people, the property or itself (Lorenz et al., 2015).

Simulations

A simulation is an approximate imitation of the operation of a process or system. It can be used in many contexts such as optimization of processes, testing, training, education etc. Simulations also play a huge role in product design. Throughout the simulations, people will be able to learn a lot and avoid obstacles. Simulations can be used with virtual reality, which helps people to see all important details and improves understanding of the exact simulation. One can also learn a lot by observing other workers in the simulator (Lorenz et al., 2015).

Computer simulation is an attempt to model a real-life or hypothetical situation on a computer. Later on, it can be studied to see how the system really works. While the simulation is running, we can change variables and observe predictions about the behavior of the system. A simulation is a tool to virtually investigate the behavior of the system studied. Computer simulations became very interesting in physics, chemistry, biology, human science, economies and also engineering (Banks, Carson, Nelson & Nicol 2010).

Manufacturing represents one of the most important applications of simulation. This technique proves to be a very valuable tool by engineers when evaluating the effect of capital investment in equipment and physical facilities like factory plants, warehouses and distribution centers. Simulations can also be used to predict performances of existing or already established systems. Simulations can also quantify system performance with common measures: bottlenecks, utilization of resources, system cycle time and similar. (Benedettini & Tjahjono, 2008)

Horizontal and Vertical System Integration

Horizontal integration in Industry 4.0 is explained as connected networks of cyber-physical and enterprise systems. This introduced levels of automation that have never been seen before, bringing flexibility and operational efficiency into the production processes. This kind of horizontal integration takes place at several levels: on the production floor, across multiple production facilities and across the entire supply chain (Manufacturing Business Technology, 2019).

On the other hand, vertical integration in Industry 4.0 aims to bring closer all logical layers within the organization from the production floor up through R&D, quality, IT, sales and marketing and so on. Data flows freely and transparently up and down these layers. This enables that both strategic and tactical decision can be data-driven (Manufacturing Business Technology, 2019). With industry 4.0 and cloud services, automated processes, departments will become much more cohesive (Lorenz et al., 2015).

Industrial Internet of Things

The term “Internet of things” was first mentioned in 1999 by Kevin Ashton, co-founder of the Auto-ID Center at MIT at a presentation for Procter & Gamble. Wanting to bring radio frequency ID to the attention of P&G's senior management, Ashton called his presentation "Internet of Things" to incorporate the cool new trend of 1999- the internet. The Internet of Things is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Rouse, 2019).

The definition Internet of Things comes out because of convergence of multiple technologies: real-time analytics, machine learning, commodity sensors and embedded systems (wireless sensors, control system, automation and others). In the consumer market, IoT technology is most synonymous with products that support one or more common ecosystems and can be controlled via smartphone (Rouse, 2019). With the help of industrial IoT, manufacturing machines will be connected and enriched with embedded computing. This will allow real-time responses and decision making (Lorenz et al., 2015).

Applications of IoT devices are divided into four categories: consumer, commercial, industrial and infrastructure spaces. In manufacturing, we can see more and more integrated sensors for sensing, identification, processing, communication, actuation and network capabilities. Creating this high cyber-physical space opens manufacturers’ door to create whole new business and market opportunities. The IoT intelligent systems enable a dynamic response to product demands and real-time optimization of manufacturing production and supply chain networks (networking machinery, sensors and control systems together) (Ersue, Romascanu, Schönwälder, & Sehgal, 2015).

The digital control system of IoT devices enables to automate process controls, operator tools and service information systems. IoT can also be used to predict maintenance, statistical evaluation and measurement to maximize reliability (Tan & Wang, 2010).

Cybersecurity

With a lot of connectivity, there will also be risks of cyber-attacks on companies with Industry 4.0. Therefore, cybersecurity will play an important role to protect critical industrial lines and information. In recent years companies that provide industrial equipment have joined forces with cybersecurity companies through partnerships (Lorenz et al., 2015). The era of information explosion brings additional social concern. This is the responsible handling of data. Data should not be available and accessible to everyone, especially if it is confidential or more sensitive. (Wakim, 2019).

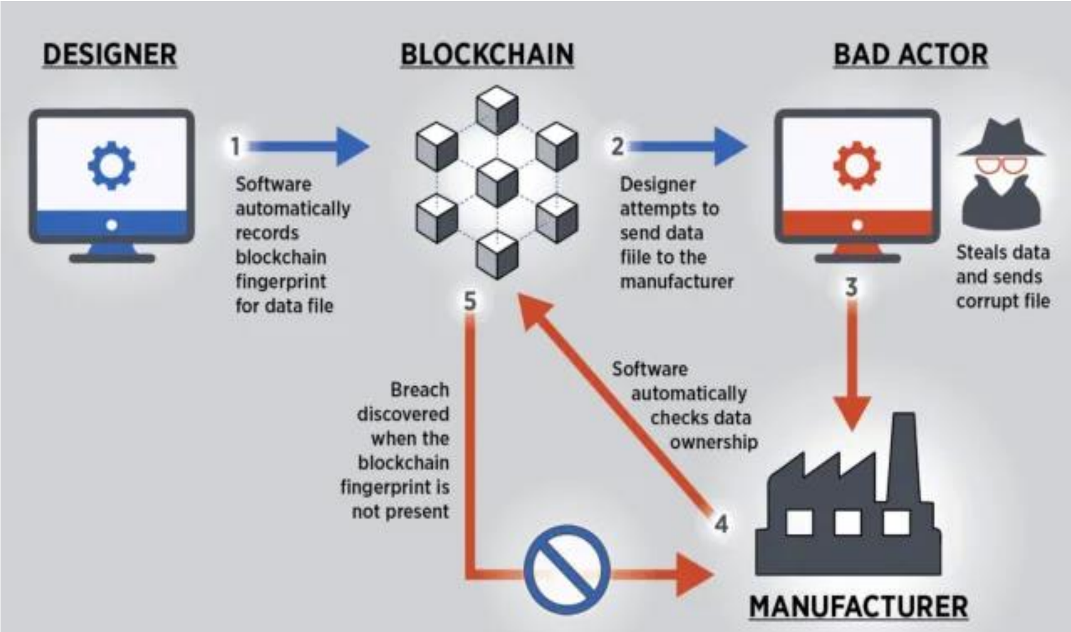
Things within the system that are connected to the Internet need to have pre-determined security strategies. The rapid connectivity of devices in the network of the Internet of things is leading to serious security threats. The areas to take into consideration in determining the security strategies of things used in Industry 4.0 space are summarized below:

- Privacy: The data generated by the objects must be accessible only by the authority (user or other devices). Communication of interconnected devices must be done over a specific topology.
- Integrity: Ensuring that the data comes from the right place and reaches the destination safely without being changed.
- Usability: To ensure the availability of the data needed by the devices or services in the network within the system.
- Authorization: It is the identification of things within the network and the editing of the verification mechanism.
- Lighting Solutions: It is the determination of the compatibility of IoT features such as the number of devices in the network and power capacity in determining security solutions.
- Heterogeneity: Represents that things with different manufacturers have collaborative working architectures.
- Policy: Establishing IoT standards for the management, protection, and communication of data within IoT.
- Encryption System: The identification of encryption algorithms for the protection of data during devices data communication (Süzen, 2020).

Blockchain

A blockchain is a growing list of records, called blocks that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (Iansiti & Lakhani, 2017). The blockchain technology has the potential to handle various security attacks as it can eliminate the need for the centralized authority to perform various operations. In the blockchain technology, several users participate in transaction verification and validation. So far there have been three blockchain versions, with the first technology presented in 2009 as part of the Bitcoin network. For the industrial world, the Blockchain 3.0 and 4.0 are important, since different research areas started using the technology, from IoT, supply chain and various other business applications. Blockchain 4.0 generation mainly focused on services such as public ledger and distributed databases in real-time. This level has seamless integration of Industry 4.0-based applications. It uses the smart contract, which eliminates the need for paper-based contracts and regulates within the network by its consensus (Bodkhe et al., 2020). Figure 2 presents the benefits of Blockchain usage in manufacturing.

Figure 2: Blockchain in manufacturing



Source: Heimgartner (2019)

Cloud Computing

Cloud services enable on-demand network access to a shared pool of computing resources. This technology has the capacity to store data in an internet server provider which can be easily retrieved through remote access (Mell & Grance, 2011).

The cloud business is a key factor in the fourth Industrial Revolution. Since Industry 4.0 collects data through automation, the internet of things and robotics, storing information plays an important role. This is where the cloud solution comes into play. The exponential growth in the volume of data is driving the industry to develop new models and tools to process large-scale data. There are two important concepts - cloud solution and extensive data. Data refers to a huge amount of data, while cloud business talks about infrastructure. The combination of both brings a useful result for organizations as it offers a comprehensive and cost-effective solution for data analysis (Vermi, 2018).

The term Cloud was first introduced for the service transfer process and applications to the internet. The cloud solution provider allows users to save applications and files to remote servers. It can be accessed through the Internet where the information the user wants to access is in the cloud. It is up to date and can be accessed from anywhere as well as anytime the user desires (Jain, 2018).

Many organizations, whether large or small, use cloud technology for different purposes. Cloud solutions are used for (Jain, 2018):

- Development of new applications and services,

- hosting blogs and websites,
- storing, backing up and restoring data,
- streaming videos and sounds,
- analysis of forecast data.

The cloud offers businesses the right environment to adapt to today's fast-changing technologies. Industries can with unmatched capabilities of computing, storage and networking use a cloud-based optimization platform of their business processes, to run their applications flawlessly and eventually get data and analytics insights.

Augmented reality

Augmented reality allows the user to have an interactive experience of the real-world environment where the real-world objects are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities (Augment, 2016). The primary value of AR is the manner in which components of the digital world blend into a person's perception of the real world. It is not shown as a simple display of data but through the integration of immersive sensations, which are perceived as natural parts of an environment. AR is usually a compound of hardware and software parts (The Franklin Institute, 2018).

Figure 3: Augmented Reality in manufacturing

Source: Porter & Heppelmann (2019)

AR can be used for many applications, from gaming and entertainment to medicine, education and business. Nowadays we can find AR in different areas such as architecture, commerce, industrial manufacturing, visual art and others. In industrial manufacturing, companies could save a lot of paper by using AR and substitute their manuals with digital instructions which are overlaid on the manufacturing operators' field of view, reducing mental effort required to operate. It also helps with maintenance, because it gives direct access to machines maintenance history (Gattullo, et al., 2019).

When it comes to Industry 4.0, we can say that this system supports a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices or just use it for educating people or any other capabilities. These systems are currently not so often used, but in the future, companies will expand the usage of augmented reality to provide workers with real-time information to improve decision making and work procedures. This will help companies to improve productivity, cost-saving and will bring other benefits (Lorenz et al., 2015).

Virtual reality

Virtual reality is a simulated experience that can be like or completely different from the real world. It can be used for entertainment or educational purposes (especially medical or military training). Methods how VR can be realized are simulation-based and avatar image-based VR. An example of simulation-based VR is a driving simulator where it gives the driver on board the impression of actually driving an actual vehicle by predicting vehicular motion caused by driver input and feeding back corresponding visual, motion and audio cues to the driver. But with avatar image-based VR people can join the virtual environment in the form of a real video. The user can select his/her own type of participation based on the system capability (Bardi, 2019).

Figure 4: Virtual Reality (VR)

Source: Hill (2019)

Methods how VR can be projected are projector-based, desktop-based and head-mounted display VR. Projector-based is most common when modeling of the real environmental plays a vital role such as construction modeling or airplane simulation. For desktop-based VR example, we can take most of the modern first-person video games, using various triggers, responsive characters etc. Using head-mounted display immerses users even more into a virtual reality (VRS, 2017).

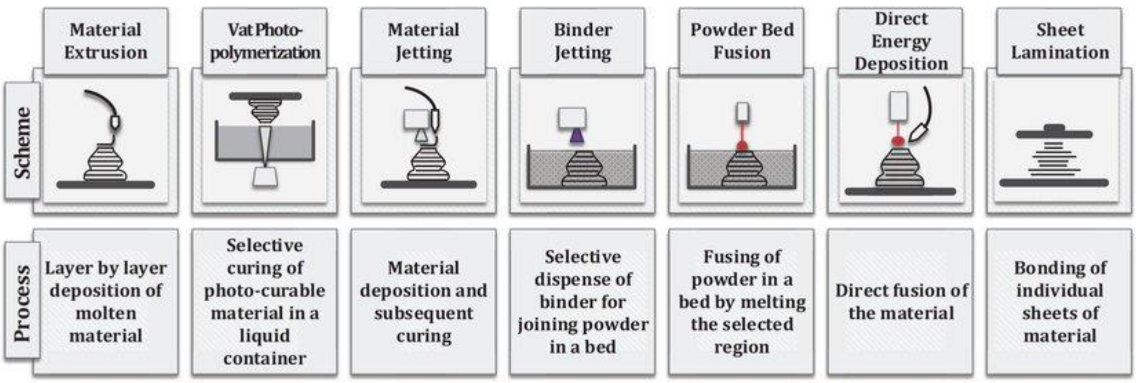
VR will play a huge part in Industry 4.0, since it will improve general education. It will help people to understand complex processes faster and train them as many times as needed, without any additional cost. This technology will help companies to train their workers and make them specialists in different fields (Kovar, et al., 2016).

3D Printing (Additive Manufacturing)

3D printing or additive manufacturing is a process of making a three-dimensional solid object from a digital file. 3D printed object is achieved by using additive process, where the object is created by laying down successive layers of material until the object is done. Each of those layers is a thinly sliced horizontal cross-section of the eventual object. 3D printing is also known as the opposite process of subtractive manufacturing.

Additive manufacturing can be done in different ways that are presented in Figure 5. The most common is with material extrusion where the plastic filament is preheated in the nozzle and applied layer by layer.

Figure 5: Methods of 3D printing



Source: Amziane (2019)

Companies have been lately using additive manufacturing more frequently in their business models. 3D printing, which is mostly used for prototyping and producing individual components. With Industry 4.0, these additive-manufacturing methods are widely used for the production of small batches and customized products that offer construction advantages, such as complex, lightweight designs and fast modifications. High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand, boosting innovation (Lorenz et al., 2015).

Because the reliability, safety, speed and quality of 3D printers are improving, and they are getting cheaper, 3D printers are set to play an important role in this digital transformation of the industry. As the performance of additive manufacturing improves rapidly, and the cost decreases, new opportunities will arise that will take 3D printing ever closer to mass production. This technology will help mostly automotive and large manufacturing companies, due to the significant cost savings and customizations (DesigneTech, 2018).

Big Data

Big data refers to data sets that are usually too large or complex to be dealt with traditional data-processing application software. Researchers in this field try to extract useful information from the gathered data. Big data include data capturing, data storage, data analysis, sharing, transfer and similar. Big data is playing a huge part in Industry 4.0 because as we see, all above-mentioned technologies are gathering information and storing them. With analyzing this data, we can reduce cost, improve supply chain and many other activities, which leads to better productivity and profitability of the company. We can say that big data is somehow transforming data to value (Control Station, 2019).

Digital twin

A digital twin enables a view into an automatized system or simulation based on different data models. It is a digital representation of physical objects, systems, people, places or devices. It provides both the elements and the dynamics of how IoT device operates and lives throughout its life cycle. This is the reason why it appears more often where people design or use IoT devices. The connection between the physical model and the corresponding virtual model is established by generating real-time data using sensors (Saddik, 2018).

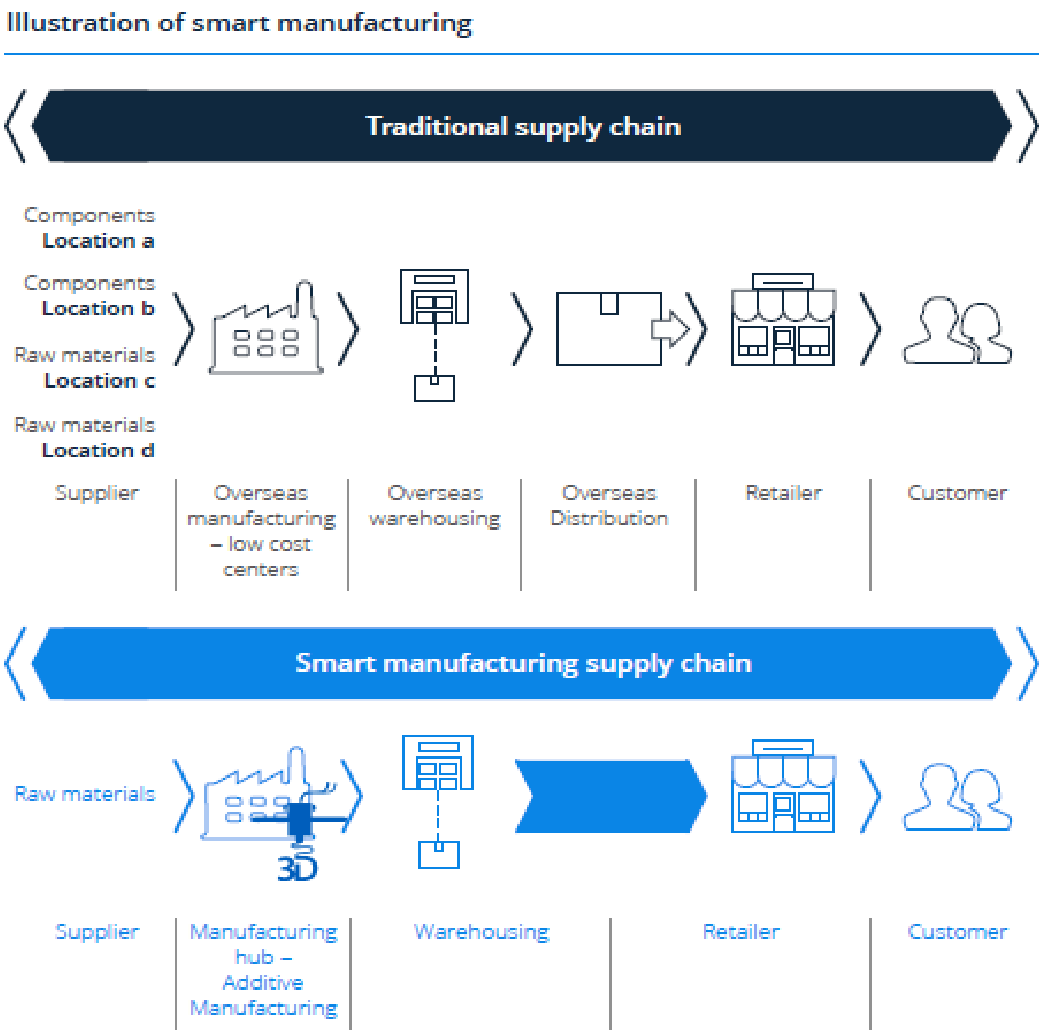
The most common use is for managing the buildings, machinery and other systems where sensors and gathered data enable smart management of the systems. Some main areas of digital twins usage are control of resources, simulation and preparation of responses to certain situations. They are also used for improvements in processes and for training employees how to act in different situations (Monitor, 2019).

1.2 Advantages of the Industrial Revolution from an economic and technological point of view

The fourth revolution is expected to bring flexible manufacturing processes by analyzing large amounts of data in real-time, improving strategic and operational decision-making. Technologies mentioned in the previous chapter enable the three main advantages of

Industry 4.0 such as vertical integration, horizontal integration, and end-to-end engineering. Integration helps business operations, by communicating between machine and products, which results in flexibility in production, even for small batches. With Industry 4.0, new opportunities and benefits for business growth also arise. With the horizontal integration concept and collaborative networks among enterprises, one can combine resources, divide risks, and quickly adapt to changes in the market, seizing new opportunities (Frank, Dalenogare, Benitez & Ayala, 2018).

Figure 6: Traditional supply chain compared to the smart manufacturing one



Source: Mehta & Hamke (2019)

As seen in Figure 6, smart manufacturing will result in a less complex supply chain. Since in-house additive manufacturing and smart warehousing will eliminate overseas manufacturing and distribution. Smart Manufacturing will Make supply chains demand driven not forecast driven.

Companies who will successfully adapt Industry 4.0 will have advantages such as optimization, customization and also experience improvements in R&D. Studies have shown that smart factories with smart devices are utilizing production constantly, leading to reduced production times which result in increased profit in companies (Luenendonk, 2017).

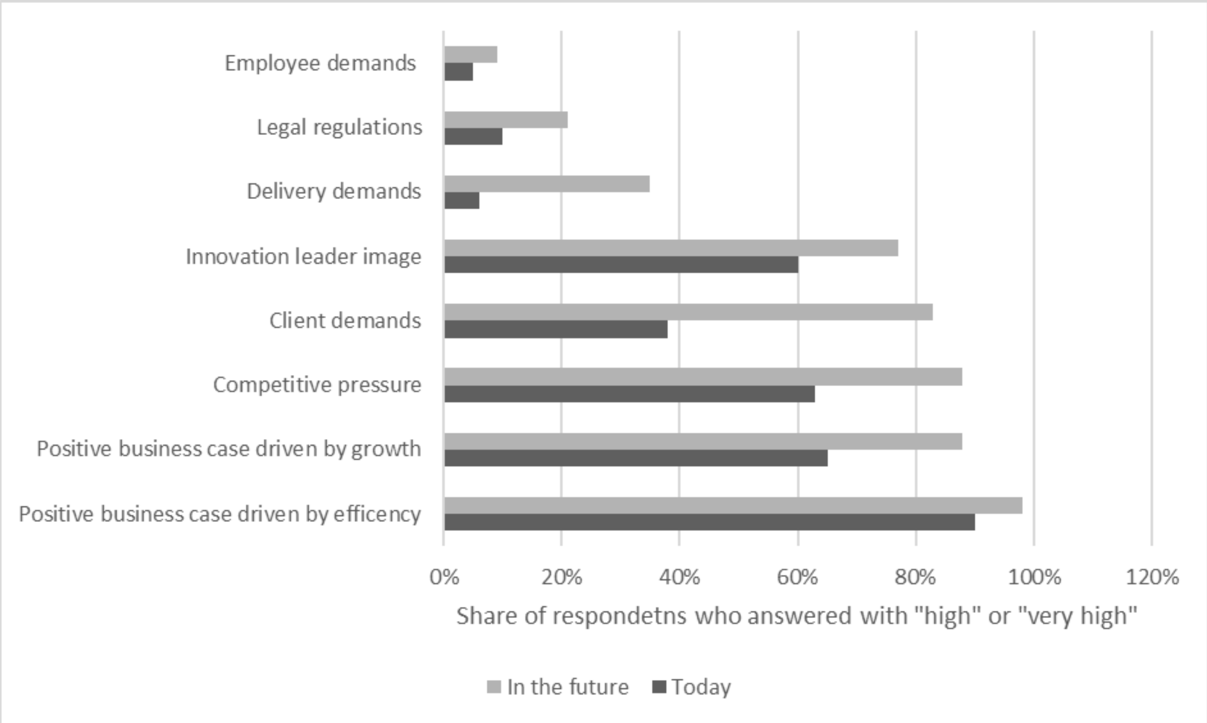
Industry 4.0 will certainly provoke changes in business and company models. Rather than exclusively competing on cost like before, European companies will also compete on the basis of innovation (to design and deliver a new product fast), on the ability to produce customer-driven customized designs (through configurable production), or on quality (by reducing faults with the help of automation and control). Some companies will take advantage of the data created as 'smart' products are created and used, with adapting business models based on selling services, not products. Those steps can help to expand business opportunities and increase revenues (European Union, 2015).

Many economic theories explain the implementation of new technologies and the substitution of labor by capital as the actions needed to reduce costs, increase productivity, and allow to produce individual customer solutions. Those actions are taking place in all industries. So far most of the studies have been concerned with manufacturing industries, although the Industry 4.0 initiative is relevant in all sectors (Maresova et al., 2018).

Industry 4.0 is expected to have a major impact on global economies, more than previous revolutions had. Industry 4.0 can deliver estimated annual efficiency gains in manufacturing of between 6% and 8%. The Boston Consulting Group predicted that in Germany alone, Industry 4.0 will contribute 1% per year to GDP over ten years, creating up to 390.000 jobs. Globally, one expert estimates that investment on the Industrial Internet will grow from USD 20 billion in 2012 to more than USD 500 billion in 2020 (albeit with slower growth after that date) and that value-added will surge from USD 23 billion in 2012 to USD 1.3 trillion in 2020 (European Union, 2015).

Based on the Statista survey, conducted in 2015 in the EU, the three main reasons for investing in Industry 4.0 are positive business cases driven by efficiency, cases driven by growth and competitive pressure. The least common reason for investing is the “Employee demands” since employees are mostly scared of being replaced by machines. The detailed projection of reasons is presented in Figure 7.

Figure 7: Reasons for investing in Industry 4.0 projects in year 2016 in the DACH region



Source: Statista (2016)

1.3 Industry 4.0 environmental impact reduction

The footprint of human impact on Earth has lately generated much scientific concern. Advances in recent decades in scientific monitoring and data collection, processing and modelling have enabled scientists to better assess and forecast the impact of human development on environmental systems. The findings are worrying, since because of the historical, cumulative human footprint, many scientists' research suggests that the Earth could be entering a period of unprecedented environmental systems change.

The potential to harness the Fourth Industrial Revolution to help transform how humanity manages its environmental footprint and, more fundamentally, to re-imagine how human and economic systems might interact with the natural world appears potentially boundless. Areas such as transport, connected products, product traceability, blockchain, emissions monitoring will drastically reshape in this Industrial Revolution, leading to greener solutions (World Economic Forum, 2017).

1.3.1 Green transport

Advanced materials and technologies are enabling breakthroughs in battery design. The growing market for electric cars is forecast to displace oil demand by approximately 2 million barrels per day by 2025, rising to 16 million by 2040. (PWC, 2018). Meanwhile, scientists have described moves to further extend autonomous vehicles. There is a risk that technology, data, expertise, and decision-making will become concentrated in the hands of a relatively small set of market leaders. Technology companies have become direct competitors of traditional automotive companies, and it is the mobility services software, not the hardware, where competition is most fierce. This creates a new governance challenge, which spans multiple industry sectors and technology sets and requires cooperation between the public and private sectors.

The advances in IoT technologies and network capabilities hold great promises. In China, there are digital car-ride companies. They receive more than 20 million orders daily, twice the number of rides of all other markets in the world, operating in 400 cities across China, engaging 17.5 million drivers, and car-pools approximately 2 million passengers daily. This pooling is taking approximately 1 million vehicles off the roads each day. It is estimated that this will greatly reduce greenhouse gas emissions with CO2, along with providing the associated benefits of reduced air and Hydrofluorocarbon (HFC) pollution from vehicle air conditioners. New public-private platforms are under development to help cities in China share information locally and globally about: how to enable car-sharing to reduce pollution; how to redesign city streets to enable these innovations; and how to work with the car and truck industry to accelerate production of electric vehicles designed for passenger sharing/optimal logistics delivery and ready for autonomous driving.

AI combined with machine learning algorithms can be beneficial not only for smart transportation but also for green transportation. Currently, AI is massively used to optimize navigation and increase safety, congestion and traffic flows. Over coming years and decades, AI guided autonomous vehicles will enable a transition to mobility on demand. With new autonomous vehicles and their ability to be interconnected, new reductions in greenhouse gases can be achieved. Some of the solutions are:

- Route optimization that reduces driving miles and congestion.
- Eco-driving algorithms that priorities energy efficiency.
- Autonomous ride-sharing service that reduces vehicles miles travelled and car ownership (PWC, 2018).

1.3.2 Geospatial data & monitoring emissions

Geospatial data monitoring platforms utilize advanced sensors and satellite imagery, combined with big data analytics, to enable anyone with a smartphone to track and monitor activity within important environmental systems. These are just the first releases – future iterations could leverage AI, such as machine learning to forecast where illegal fishing or logging is likely to occur. These platforms will generate, but also rely on, a wealth of data gathered from multiple sources, potentially including satellites, ships, ocean drones and DNA sequencing. As part of this project, a dialogue is already underway to explore how alliances among data providers and data processors can help them to better apply their collective efforts to the challenge of environmental management.

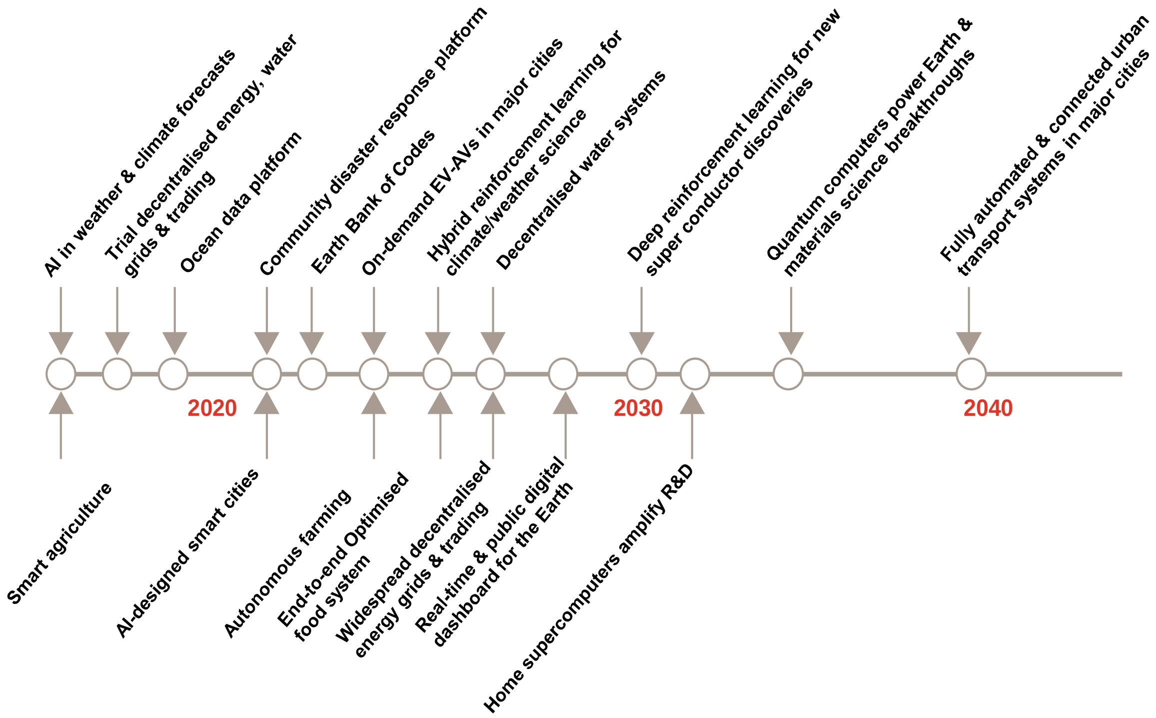
Rapid advances in satellites, drones and advanced sensors – augmented by smart algorithms or AI technology – could provide a real-time flow of data on GHG emissions, which would then be relayed across the cloud to be tracked by anyone from government officials to schoolchildren. This would greatly improve the transparency of Monitoring, Reporting and Verification data, which is crucial for the accountability and efficacy of global climate agreements. The political implications could be transformative, as could be similar real-time satellite and drone monitoring of industrial GHG emissions for investors, insurers, and regulators. No longer would disclosure regimes rely on companies choosing when and how to report. Instead, the information would be available, possibly in the blockchain, for all to see and to act upon (World Economic Forum, 2017).

1.3.3 Earth-friendly disruptive innovations based on AI

Current environmental issues could be minimized by AI, which has enormous potential. AI, in combination with other Fourth Industrial Revolution technologies, have huge potential to deliver transformative solutions which could have an impact on the environment.

Game changers which could transform our environment are for example autonomous and connected electric vehicles, distributed energy grids, smart agriculture, weather forecasting and climate modelling, decentralized water, AI-designed intelligent, connected and livable cities, Earth bank of codes and others. Figure 8 shows the indicative timeline when AI for the Earth will probably be applied. In-between 2020 and 2030, AI is planned to have ten new solutions which could reduce the impact on the environment (PWC, 2018).

Figure 8: Indicative timeline of application of Earth game changers



Source: PWC (2018)

Autonomous and connected electric vehicles

AI will have a huge part in the connectivity of electric vehicles, which will ultimately transform short track mobility, while reducing emissions of harmful gasses and delivering cleaner air. With the help of machine-learning, transport will be more efficient and communication between vehicles will enable to identify traffic accidents while optimizing navigation and network routes. With the help of big data, electric vehicles charging will become way less expensive with demand-response software programs. A new way of transportation (clean, smart, connected and increasingly autonomous) will combine AI with other technologies of Industry 4.0 (Nikitas, Kougias, Alyavina, & Tchouamou, 2017).

The demand for transport will probably increase in the future, offsetting some efficiency gains, but overall a smart transport system enabled by AI can be expected to lower emissions and help preserve the environment. Improved efficiency could also result in a completely new way of transportation like car-sharing and reduced car ownership, which further leads to lower emissions from manufacturing and operating vehicles (Nikitas, Kougias, Alyavina, & Tchouamou, 2017).

Distributed energy grids

The energy industry makes more and more use of machine learning, including deep learning algorithms. AI can help to predict demand and supply of renewable energy, improve energy storage and load management, assist in the integration and reliability of renewables and enable dynamic pricing and trading. Plants which are AI capable or so-called virtual power plants can integrate, aggregate and optimize the use of solar panels, microgrids, energy storage installations and other facilities. The Solar road is only one example of how we can benefit from renewable energy. With the help of AI, a road could learn when to heat up and melt the snow or to adjust traffic lanes based on vehicle flow (Mohd, Ortjohann , Schmelter, Hamsic, & Morton, 2008).

Smart agriculture

It is expected that different areas of agriculture will make use of enormous automated data collections and make their farming decisions based on the gathered information. It will allow them to optimize their spraying and harvesting. Newer technologies will also allow them early detection of crop diseases and other issues. Generally, farmers will have their agricultural inputs and returns optimized. This will lead to increased resources efficiency of the agriculture industry, lower use of water, fertilizers and pesticides which are creating runoff into rivers, oceans and insect populations, causing damage to important ecosystems (Intetics, 2020).

A community disaster platform

These days natural disasters occur more frequently than in the past. They mostly result in economic losses or human suffering. Thanks to the technology advancements, scientists are able to predict many disasters before they occur, which helps people and companies act accordingly. But people still often react too late due to lack of information, analytical insight and awareness of the best course of action. Damage of future natural catastrophes can be mitigated with the help of resilience planning. With the help of AI, multidimensional data about a region can be analyzed, resulting in different aspects that have an impact on resilience. AI can run and analyze different scenarios of different weather events and disasters in a region to seek out vulnerabilities and identify the saliency plans (Sarvai, Nozari, & Khadraoui, 2019).

Decentralized water

Water resource could be optimized by machine and deep learning. AI can be used to equally distribute “off-grid” water resources, analogous to decentralized energy systems. Households equipped with a smart meter can produce large volumes of data that can be analyzed to predict water flows and shortages. Such measuring systems can also spot inconsistencies and leaks. In the future, the mentioned systems could be merged with machine learning, IoT and other technologies allowing truly decentralized water system. Local resources and closed-loop water recycling will gain more value in the future. Additionally, blockchain could be used for trading water resources (PWC, 2018).

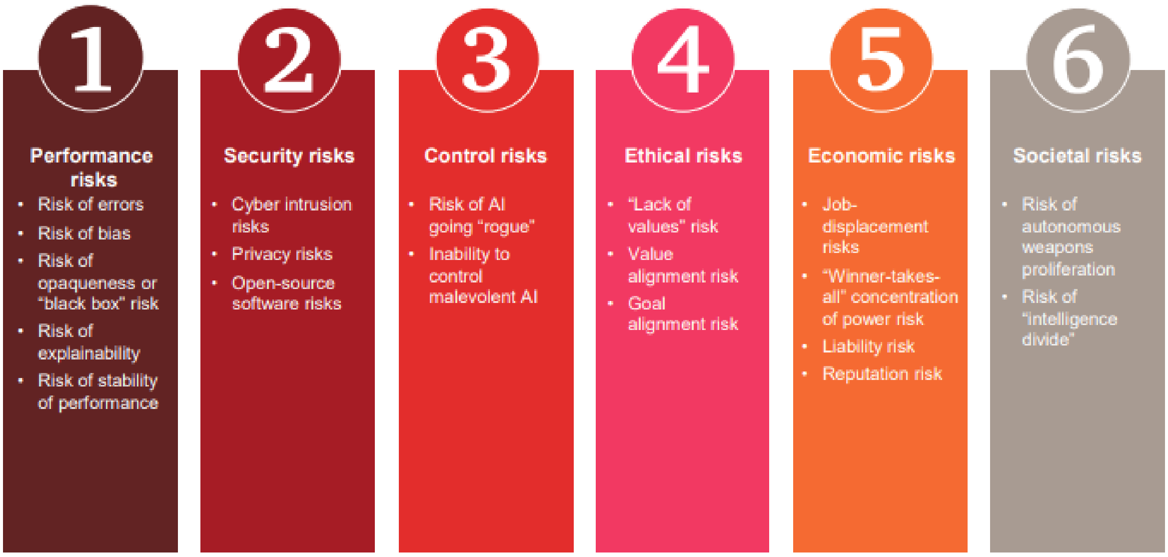
AI - cities

AI will not only be present in autonomous vehicles, but also in cities and urban planning in general. With the help of deep learning, cities will become resilient, human-centered with less air pollution and environmental impact. AI-generated data could be in combination with AR and VR used by architects and city planners, to help them design more efficient cities. Officials responsible for ensuring disaster preparedness could also make use of that data. As mentioned before, smart meters with the help of AI and IoT will help forecast and optimize urban energy and water generation based on demand. The real-time city-wide data on energy and water supply and demand, various traffic flows, people flows, and weather could be displayed on an "urban dashboard". With the addition of AI, cities could become more efficient, resulting in reduced pollution and congestion. Everything could be optimized from water and energy use across the city, potentially reducing the need for costly additional infrastructure. (Vander Ark, 2018).

1.3.4 Unintended AI consequences for the Earth

AI brings along many benefits from building a sustainable planet for future generations to making our lives easier, however it also poses short and long-term risks. Those risks are classified in the categories below and have varying impacts on individuals, organizations, society and our planet.

Figure 9: AI consequences



Source: PWC (2018)

Performance risks

Mostly all AI system outputs are determined within a “black box”. Those do not provide transparency and are not to be trusted. The algorithms used in AI are mostly difficult to explain. Some of them are so complex that humans still cannot understand. Being unable to understand the processes behind the AI outputs also makes humans doubt the performance of AI algorithms, making them less desirable. Nowadays, the ongoing research aims to reduce “model bias” resulting from biases in training data, and to increase the stability of model performance. It is important that humans keep track of all algorithms outputs to mitigate these unintended biases and wider performance risks (Cheatham, Javanmardian, & Sam, 2019).

Security risk

AI raises the new risk for global safety. The misuse of AI via hacking is a serious risk, as many algorithms being developed with good intentions could be repurposed for harm. It is the governance’s turn to build explain-ability, transparency and validity into the algorithms. They should not forget to define the border between beneficial and harmful AI. Appropriate governance will be required to ensure human and Earth-friendly AI and prevent misuse (PWC, 2018).

Control risk

Nowadays, AI systems work autonomously and interact with one another, creating machine-centered feedback mechanisms that can cause unexpected outcomes. For example, one type of control risk would be when chatbots interacting with one another could create their own language that humans cannot understand. Monitoring, safeguards and proactive control are necessary to prevent such issues before they become a serious problem (Deloitte, 2018a).

Ethical risk

Responsible or ethical use of AI involves three main elements:

- the use of big data,
- the growing reliance on algorithms to perform tasks and make decisions,
- the gradual reduction of human involvement in many processes.

All the above-mentioned elements raise issues related to human rights, from fairness and responsibility, to equality and respect. Additionally, while biases AI outcomes can raise significant privacy concerns, many insights and decisions about individuals are based on inferred group or community attributes (Cheatham, Javanmardian, & Sam, 2019).

Economic risk

When a company adopts AI, it may help them in the competitive landscape. Either they become winners by adopting the technologies, or losers if they lack knowledge and are unable to implement AI. Making decisions with the help of AI could be beneficial, because decisions can be made faster and more accurately. Companies that struggle in the AI transition may be forced to reduce investment, possibly impairing their sustainability performance. Tax-base erosion presents another economic threat as the current system, based on "bricks and mortar" and nation-states, struggles to keep pace with the globalized digital economy (Deloitte, 2018a).

Social risk

With automation being used in almost every sector, especially employment in transportation, manufacturing, agriculture and the service sector might be at risk. This might result in higher unemployment rates that could lead to greater inequality and stressful times. Algorithms developed by a subgroup of the population at national and global levels can lead to unconscious biases, which can lead to results that marginalize minorities or other groups. Autonomous weapons also pose a significant threat to society, possibly permitting bigger, faster conflicts (PWC, 2018).

1.4 Industry 5.0

It has been less than a decade since Industry 4.0 began. The visionaries today are announcing the next revolution - Industry 5.0. The current revolution emphasizes the transformation of factories into smart IoT and deployment facilities of cloud computing. While Industry 5.0 focuses on the return of human hands and the mind to an industrial framework. The biggest progress predicted by Industry 5.0, involves the interaction of human intelligence and cognitive computer science. A combination of humans and computer machines is expected to take production to new levels of speed and perfection. Industry 5.0 will be more environmentally friendly, as companies will develop systems that operate on renewable energy (Lewis, 2017).

As in Industry 4.0, we expect that Industry 5.0 will create a new key manufacturing role: Chief Robotics Officer. A CRO will be an individual with expertise in understanding robots and their coworking with humans. The CRO will be in charge of decisions about which machines and robots will be added, removed or relocated from one part of the factory floor to another to achieve optimal performance and efficiency. CROs will need to have knowledge in robotics, AI, human factors modelling, and human–machine interaction. Their knowledge about collaborative robotic technologies combined with harnessing power from advances in computation will be crucial to make a positive impact on environmental management as well. Industry 5.0 will generally increase the sustainability by reducing pollution and waste generation and preserving the environment (Nahavandi, 2019).

1.5 Industry 5.0 technologies

To achieve the positive changes listed above, even more advanced technologies will be needed. Some of them will upgrade the current ones, while some of them will be totally new. The main ones are Networked Sensor Data Interoperability, Multiscale Dynamic Modelling and Simulation: Digital Twins, Shop floor Trackers, Virtual Training, Intelligent Autonomous Systems, Advances in Sensing Technologies and Machine Cognition.

Networked Sensor Data Interoperability

Sensing and grouping of massive information is a must within the next Industrial Revolution and is only possible through networked sensorics. With a lot of data, it is possible to faster analyze and customize processes according to market needs. A whole system of sensors with some basic intelligence and processing power would greatly reduce the demand for a high-bandwidth data transfer mechanism, while also allowing some locally based data preprocessing. This eventually would reduce overall network overload and latency, while also creating a level of "distributed intelligence" within the network. A standard framework for information transfer, rather than a simple data transfer mechanism, is required to fully benefit from a sensor network. Once the network is implemented, these sensors will open new possibilities for unique customization in manufacturing processes (Nahavandi, 2019).

Digital Twins

With the intelligence of autonomous systems, additional complexities arise in the analysis and evaluation of the manufacturing setups. Visualization and modeling of the assembly line is a very useful tool for creating policies and for managing and modifying future products and product lines. Therefore, digital twins are used. By connecting the virtual world with the real one, digital twins enhance manufacturing units with the ability to monitor the production process, manage risk prior to its occurrence, reduce downtime, and further develop by simulations and analyzed data. With recent improvements in artificial intelligence and big data processing, it is nowadays possible to create even better, more realistic and exact digital twins that properly model different operating situations and characteristics of a process. When dealing with uncertainty in the process, digital twins provide huge opportunities by reducing waste in process flow and system design. Combined with the latest visualization and modeling technologies, technologies such as digital twins can increase productivity in all sectors of all industries (Nahavandi, 2019).

Shop floor Trackers

The shop floor tracker improves real-time production tracking by allowing customer sales orders to be correlated with production orders and material supplies. Subsequently, they lead to the optimization and more effective management of resources, which is a key goal for manufacturers. The trackers also allow real-time tracking of assets and process flow. This real-time data is important for companies that want their production processes to be optimized online. These trackers are usually installed in the form of networked sensors or by utilizing the benefits offered by networked sensors. They could also lead to reduced material wastage, prevention of mismanagement of assets and theft prevention, when combined with technologies like IoT and machine learning or AI (Nahavandi, 2019).

Virtual Training

Such training existed already in 1997 and is a kind of training done in a virtual or simulated environment where the trainee learns a specific task or acquires a certain skill. Usually, the training is done in a simulator, where in some cases, the trainee and his teacher are based in different locations. This type of training is significantly cheaper and less time consuming for both parties. It is also flexible enough to be updated and reconfigured for new training courses in different areas. Usually, it is used to train drivers, pilots, firefighters, medical professionals, and similar, far from the danger and risks they might face later in the real job or without imposing risk to others. Virtual trainings are usually done by combining virtual reality and augmented reality techniques. When combined with recently improved graphical processing units, artificial intelligence and potentially big data, virtual trainings suddenly become a lot more realistic and beneficial than they were in the past. Such trainings will play a key role in creating the right and qualified workforce without putting the productivity of a running process at risk or endangering the co-workers (Nahavandi, 2019).

Intelligent Autonomous Systems

For companies to have autonomous controlled production lines, a big part of artificial intelligence applied in the software agents operating in the factory is needed. Autonomy in Industry 5.0 is much different from the autonomy that was presented as automation in Industry 3.0. It is very difficult or maybe even impossible to have such autonomy that carries out useful functions and tasks, without the implementation of artificial intelligence. AI technology allows machines to learn through different mechanisms and algorithms and therefore autonomously execute a desired task. Moreover, transfer learning is a critical feature of implementation and personalization in Industry 5.0 environments, where most of the systems suffer from unreliability. The secure and robust transfer of gained skills and knowledge from a virtual/digital system to its physical twin environment will be crucial in businesses within the Fifth Industrial Revolution (Nahavandi, 2019).

Advances in Sensing Technologies and Machine Cognition

The new autonomous systems with their own intelligence still lack important senses that humans possess. The systems will need to replicate the senses humans use to cooperate with others and learn in an adaptive manner. The basic sensory and vision capabilities of humans have already been partially mimicked by robots, by combining computer vision, deep reinforcement learning, and GPU-based computation. However, for Industry 5.0 cobots, these capabilities still must be greatly improved. For example, robots will have to stop working when they suspect something unnatural in their workspace, even when there is nothing wrong in plain sight, with using their emotional intelligence like humans do**.** Only through such predictable behavior workplace accidents will be prevented. Currently, the cognition and vision technologies are still not at the required level. Furthermore, machines will need improved cognition in order to make the best and right judgements in an ever-changing workplace situation (Nahavandi, 2019).

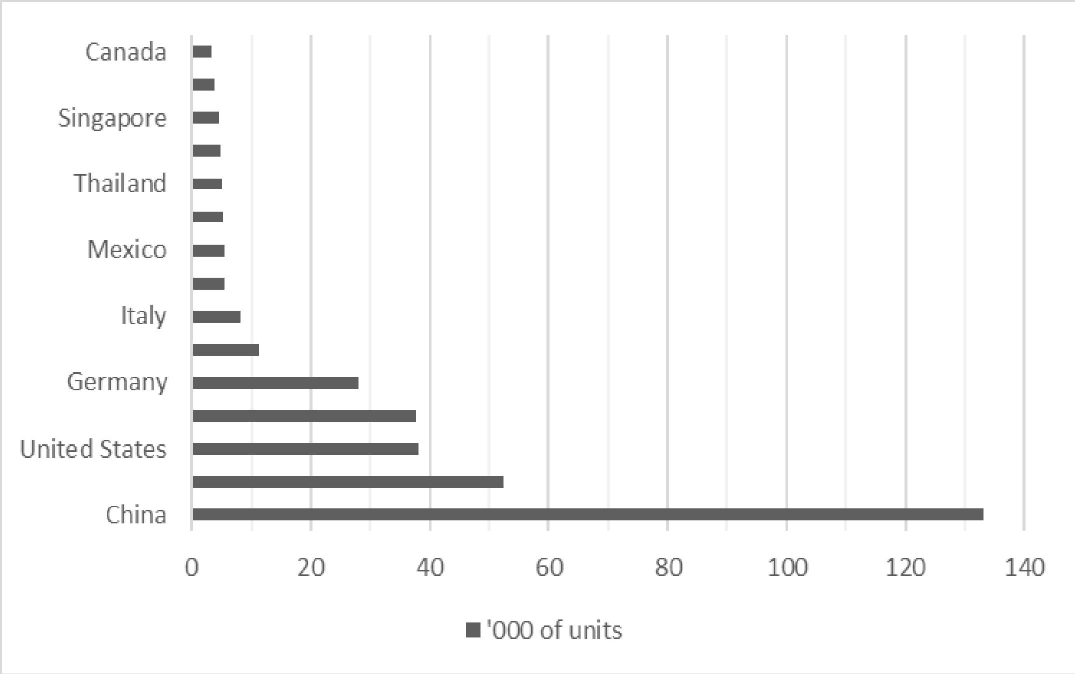
2 INFLUENCE OF NEW TECHNOLOGIES (ROBOTIZATION/DIGITALIZATION)

The digitalization of work may lead to massive job losses in the near future. There is a growing concern, especially from economists, about the effects of a rapid transformation of the job market that is based on digitalization. With robots that can work harder, longer and more efficient, especially routine jobs may become obsolete (Kieslich, 2019).

What will be the impact of the new technologies on labor demand? This is the most important question that requires an answer as new technologies keep shaping our future (Ozcan, 2017). The demand for industrial robots is actively increasing, with the growth of Industry 4.0 and smart factories. Based on the IFR Statistical Department, most robots are supplied to Asian countries like China and Japan, which resulted in an industrial growth in Asia. The worldwide estimated distribution is presented in Figure 10.

Germany is in the 5th place worldwide and in the 1st in the EU. The Germans expect that Industry 4.0 will impact mostly areas like information and communication, engineering and plant construction. A more detailed analysis of gross value added in Germany through industry 4.0 can be seen in Figure 11.

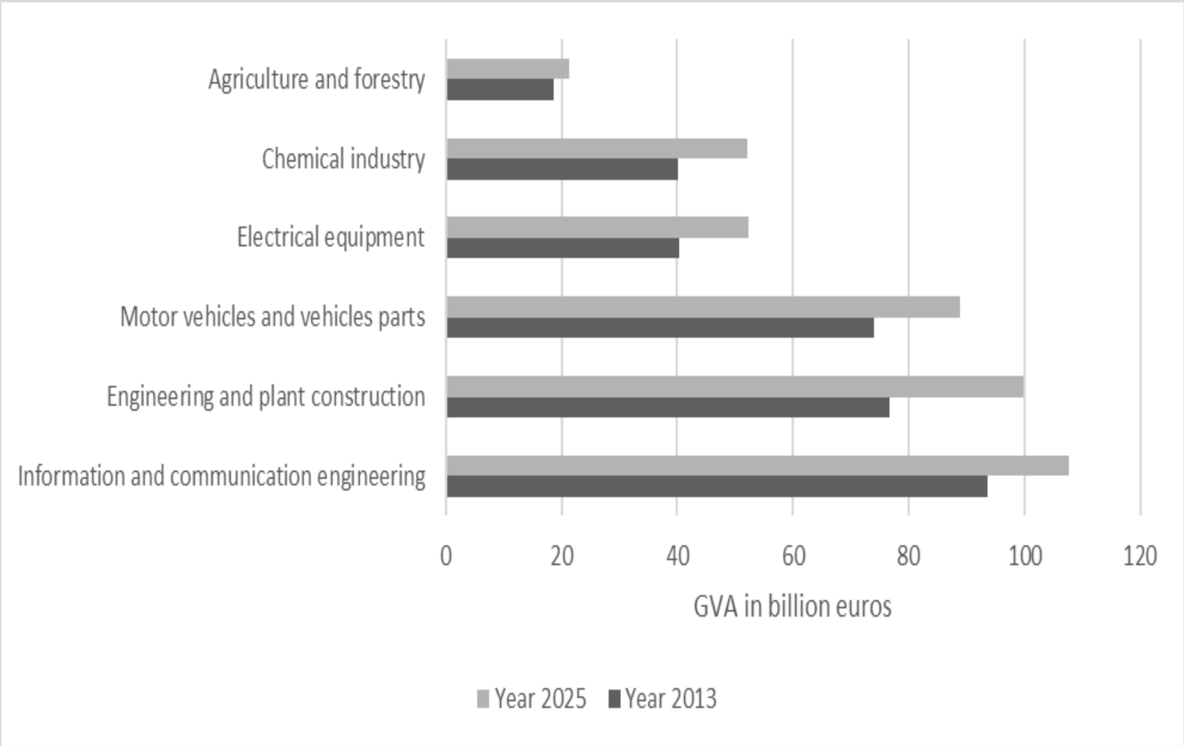
Figure 10: Estimated worldwide annual supply of industrial robots at year–end 15 main markets 2018



Source: International Federation of Robotics (2018)

74 percent of global installations in 2018 of the industrial robots were done in five major industrial robot markets: China, Japan, Republic of Korea, the United States and Germany. China remains the world´s largest industrial robot market with a share of 36% of total installations. In 2018, about 154,000 units were installed. This is 1% less compared to the previous year but more than the number of robots installed in Europe and the Americas together. The value of installations reached USD 5.4 billion – 21% higher than in 2017. With a share of almost 30% of the total supplied robots globally, the automotive industry remains the largest adopter of robots in the world (2018). In 2017 they had a great increase in installations (21% increase); this level was maintained and slightly increased by 2% in 2018. The new generation of cars requires new investments in car production capacities and modernization. Therefore, the demand for robots increased greatly. Robot investments were mainly caused by high competition in all major car markets. Car producers try to use new materials, develop energy-efficient vehicles and drive systems resulting in new technology investments (International Federation of Robotics, 2018).

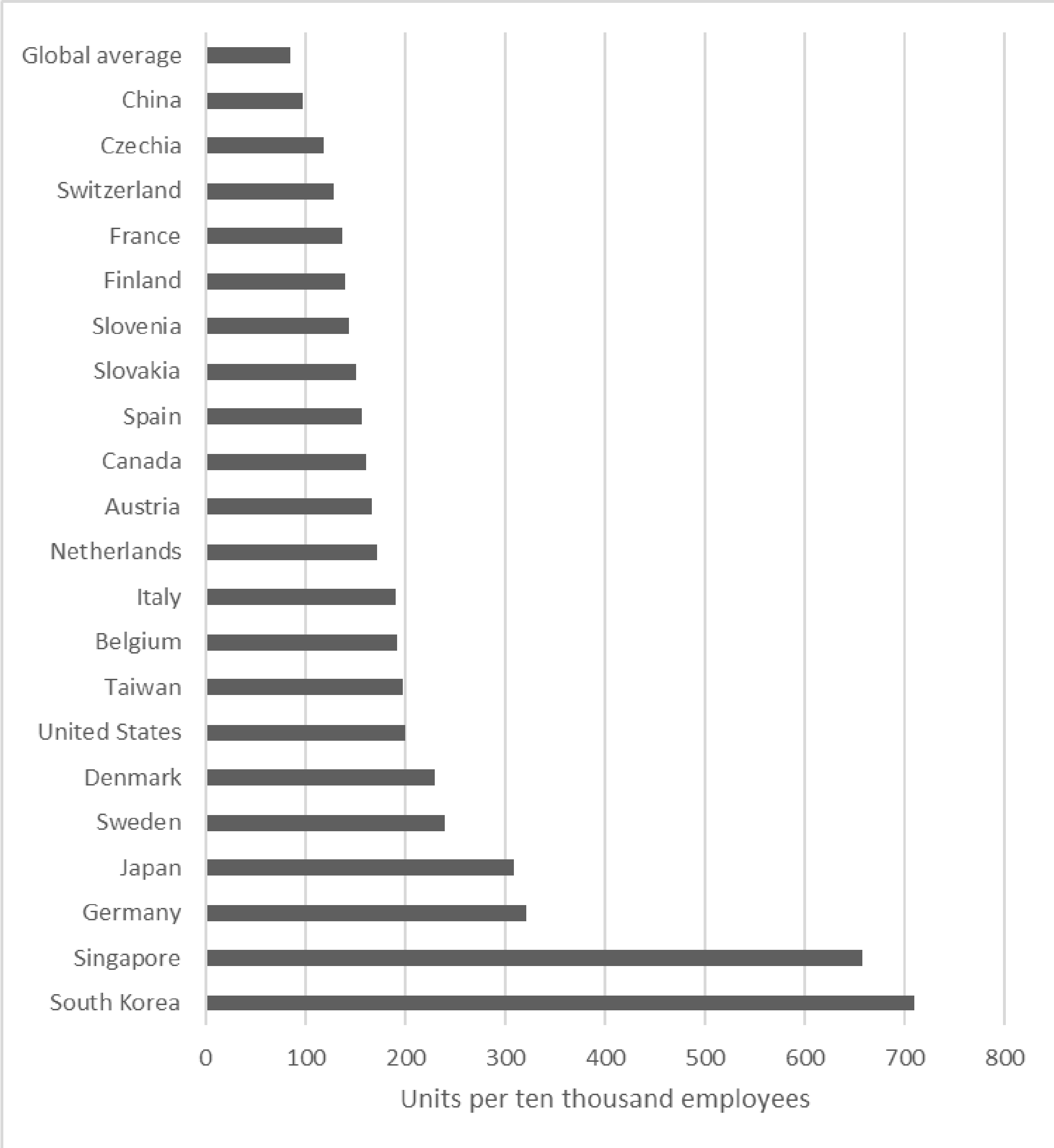
Figure 11: Forecast on the growth of GVA in selected branches through Industry 4.0 in Germany for 2025



Source: Statista (2014)

The robot density in units per 10,000 employees worldwide (Figure 12) shows that Slovenia overall was not doing badly in 2017 compared to Germany, which is usually the leading technology country. Slovenia has one-third of industrial robot units compared to Germany. Surprisingly on the first and second place are two countries which have a density of robots per 10,000 employees twice as much as Germany. That means that Germany is the leading country in Europe but not worldwide, because this place, in this case belongs to South Korea. This means that South Korea is not only leading in the number of robots but also a leading country in the sense of robotization and probably also in digitalization.

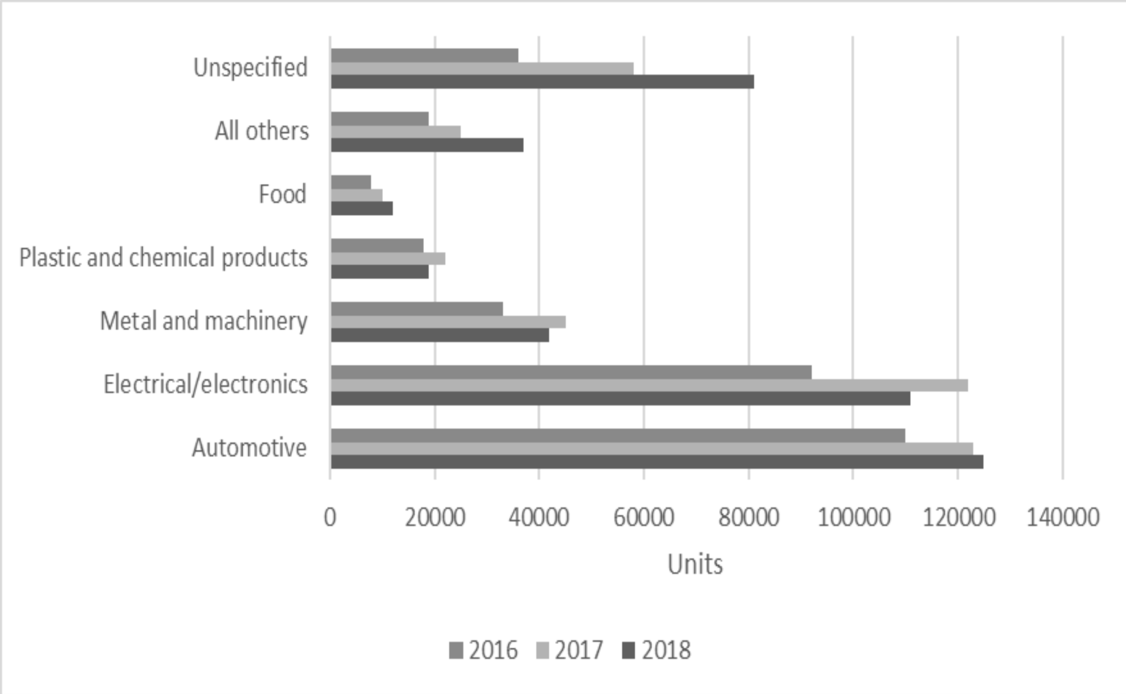
Figure 12: Manufacturing industry-related robots' density in selected countries worldwide in 2017



Source: Statista (2018)

In Figure 13, there is data for the estimated annual supply of industrial robots in the years between 2016 and 2018 and sorted by industries worldwide. Based on that we can evaluate which industry has the highest impact of Industry 4.0 and which will reconstruct the production line fastest. From the picture shown below Automotive and Electrical industries are the leading ones regarding the integration of robots in manufacture. We can say that those two industries are the most advanced because they want everything to be automated, which will help them to increase quality, decrease scrap, be more efficient and have higher margins.

Figure 13: Annual installations of industrial robots at year-end worldwide by industries 2016-2018



Source: IFR (2019)

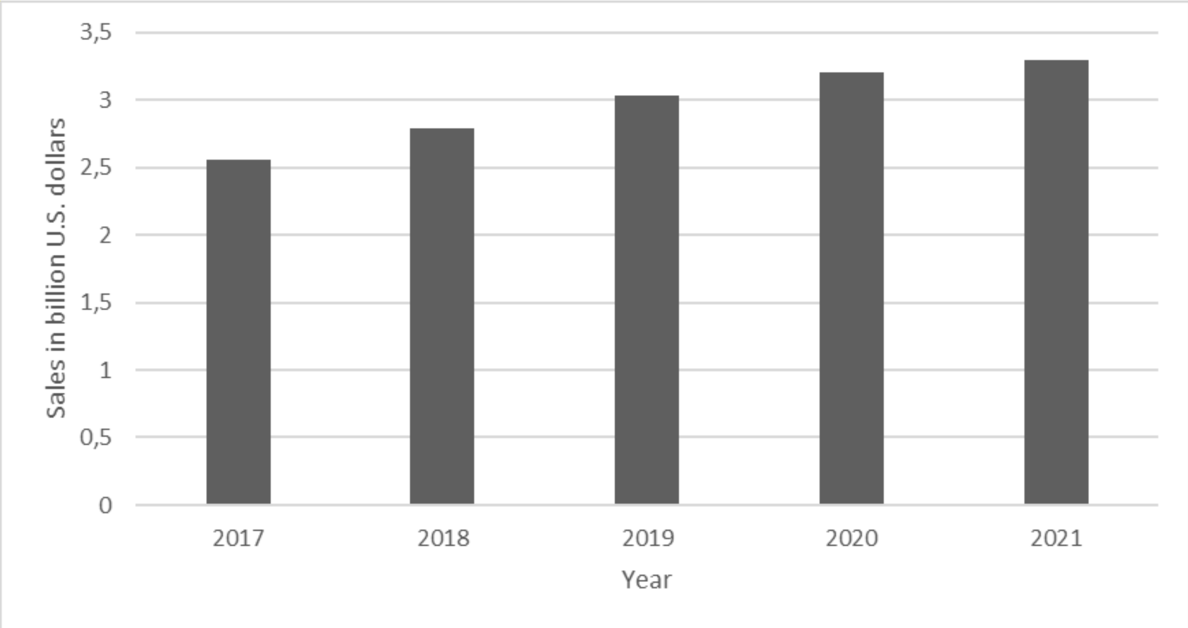
As mentioned before the automotive sector is the most important customer of industrial robots. Almost 30% of all industrial robot installations take place in this industry. After a good year in 2017 that saw a 21% increase in installations to 123,439 units, this level was maintained in 2018. Actually, a slight increase of 2% set a new peak level of 125,581 robot installations. From 2013 to 2018, annual installations in the automotive industry increased by 13% on average each year. Robot installations in the electrical/electronics industry (including computers and equipment, radio, TV and communication devices, medical equipment, precision and optical instruments) have been increasing by 24% on average each year since 2013. In 2017, they accounted for 31% of total installations and were about to replace the automotive industry as the most important customer industry. In 2018, the average robot density in the manufacturing industry was 99 robots per 10,000 employees (IFR, 2019).

Being competitive in the automotive or electrical industry means that factories in those two segments should be capable of implementing the latest technologies throughout the whole factory. They are somehow forced to use the latest technology, otherwise they are out of the competition race. These are the reasons why those two industries have such an increase in the supply of the robots. Other industries are not that dependent on robots to make them more competitive on the market since having more robots means decreasing long-term cost, improving productivity and increasing quality. These three factors are what automotive and electronics industry companies want to achieve to be better than the competition.

However, we should not forget about other industries that are also being affected by industrial robots. The metal industry holds the third place, and it is followed by the plastic industry. The difference is in the supply of new robots for the year 2018. In the first two industries, the change is negative, but the other two industries, metal and plastic, show a positive increase in supply. It is interesting that in comparison to food and beverages, the increase is not that high. We can anticipate that in food and beverages industry, robotization will soon play an important role as well. It seems that in those industries, robots are not that important to increase competitiveness otherwise, the numbers would be much higher.

The Figure 14 shows the forecast of the sales value of the industrial robotics in Europe. As we have already mentioned, every year, there are more companies that are starting to implement robots and other components which are part of Industry 4.0. This is also the reason why it is important to be up to date with new technologies and maintain the competitive level. Otherwise, you can be out of the race for new business opportunities.

Figure 14: Sales value of the industrial robotics market in Europe from 2017 to 2021



Source: Statista (2019)

2.1 Robotization

Human-robot interaction is still a complex process today, mainly because of safety issues. Manufacturers have solved these problems in the past with humans and robots working in different workspaces. That is about to change, with the development of the artificial intelligence that will allow human interaction with the next generation of robots or cobots**.** Cobots are designed to help workers gather information from systems such as the latest stock levels or the time of arrival of the shipment. They are accessible through various interfaces (web, mobile applications, etc.) (Expo, 2019). Big data is just as important for Industry 4.0 as it is for industrial robots. Many of these next-generation devices powered by artificial intelligence, use advanced datasets to monitor day-to-day operations, design reports and correct their mistakes. Cobots are especially popular with failure prediction. Cobot monitors the state of production hardware, and thus provides technicians with a report before anything goes wrong (Nichols, 2018).

Robotic systems can already proactively monitor and adapt to changes in the production line. With the networking of machines, each robot will adapt more and more dynamically not only to its work, but to other robots and humans inside the Smart Factory. Larger companies are investing in machine-based approaches to improve every aspect of production. With a higher degree of automation in a Smart Factory, fewer workers will be needed. Monotonous and dangerous jobs such as lifting heavy objects, testing chemicals will be assigned to robots. In contrast, there will be a recruitment of more skilled workers, especially software engineers and programmers (Expo, 2019).

As robotics progresses, management will need to monitor the impact they have on the psychology of people. Employees might view robotics as a threat rather than support (KPMG, 2017). A study done by Rasim Ozcan from Chief Economist Complex about robots replacing humans resulted in the following findings and recommendations:

Findings:

- Destruction effect of robotization is outpaced by job-creation effect, resulting in net jobs gains with high probability.
- The main challenge for the future of employment is not the number of jobs available; it is the form of jobs, required skills set, and acquiring those skills.
- The question is how to keep up the pace and update the skills set to fill newly created positions due to robotization whether it is a totally new or an updated version of an existing job.
- Low-skilled workers are the most vulnerable group to robotization.
- Low-skilled labor must be reallocated to new jobs by acquiring the necessary skills. Careers depend on learning new skills continuously throughout working lives.
- Gaining new skills and training is now viewed as a lifelong pursuit.

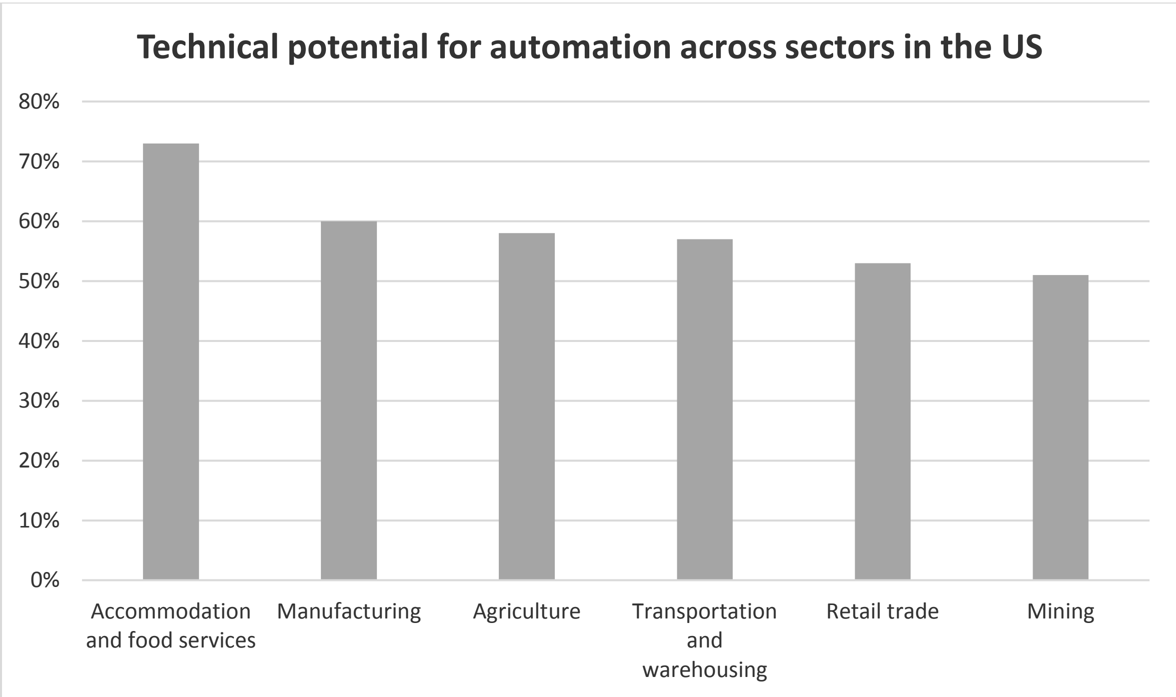
In the study, he recommended that the current education system needs to be reformed in line with the requirements of robotization and a lot of studies to fully understand the effects of robotization. Changes at country and industry level should be done (Grzybowska & Lupicka, 2017).

2.2 Automation

Automation of activities can enable businesses to improve performance, by reducing errors and improving quality and speed, and in some cases achieving outcomes that go beyond human capabilities. Based on a McKinsey research, automation could raise productivity growth globally by 0.8 to 1.4 percent annually. And almost half of the activities people are paid almost $16 trillion in wages to do in the global economy, have the potential to be automated by adapting currently demonstrated technology, according to their analysis of more than 2,000 work activities across 800 occupations. Activities most susceptible to automation involve physical activities in highly structured and predictable environments, as well as the collection and processing of data (McKinsey, 2017).

The degree of automation potential varies among sectors and countries. A significant degree of variation among sectors of the economy, and among the occupations within those sectors, emerges from the same McKinsey analysis. The sectors with the most automation potential in the US are presented in Figure 15.

Figure 15: Technical potential for automation across sectors in the US



Source: McKinsey (2017)

Factors affecting pace and extent of automation

Technical feasibility, the cost of developing and deploying solutions, labor market dynamics, economic benefits and regulatory and social acceptance will be the main factors affecting automation processes. Technology needs to be invented, integrated and adapted into solutions that automate specific activities. Deployment is useful only if the machines reach the required level of performance, reach the norms of activities. While machines can already match or outperform humans on many levels, there are still areas that need improvement. Emotional and social reasoning capabilities will also need to become more sophisticated for many work activities.

The development and engineering of automation technologies is costly and time-consuming. Hardware solutions vary from basic computers to high-tech designed, application-specific hardware such as robots with arms and other moving parts requiring dexterity and precision. Cameras and sensorics are needed for all activities requiring sensory perception capabilities, while mobility requires wheels and other hardware that enables the dynamics of machines. Over time, both software and hardware costs are reduced, making robotic solutions competitive with human labor for an increasing number of applications. Quality, quantity, as well as supply, demand, and costs of human labor are the components that determine which activity will be automated and which not. Labor market dynamics also differ geographically, not only in terms of how different and evolving demographics affect the base supply of labor, but also different wage rates and the level of education workers have. Manufacturing automation is more likely to be adopted sooner in countries with high manufacturing wages and education, such as North America and Western Europe than in developing countries with lower wages and education.

In addition to labor cost savings, a business case for automation and robotization could include performance gains such as increased profit, increased flow and productivity, improved safety, and higher quality, which are sometimes reason enough for labor substitution. The rate of adoption can be affected by circumstantial factors such as regulatory approval and the reaction of users. There are also other reasons why technology adoption takes time and does not happen overnight. The shift of capital investment into these new technologies takes time and usually is large. Changing organizational processes and structure to adapt to new technologies is also time consuming. Reconfiguring supply chains and ecosystems can be tough, and regulations sometimes are hard to change. Government policy can also slow adoption, and different businesses (by size and industry) adopt technologies at different rates. Changing the activities for workers and training them also requires dedicated effort, even if they are willing to adapt to the changes. And especially in the case of automation, individuals may feel uncomfortable about a new world where machines replace human interaction in some intimate life settings, such as hospitals, or in places where machines are expected to make life and death decisions, such as self-driving cars (McKinsey, 2017).

2.3 Lean Automation enabled by Industry 4.0 Technologies

Lean manufacturing, or lean production, is a production method derived from Toyota's 1930 operating model "The Toyota Way" (Toyota Production System, TPS). The term "Lean" was coined in 1988 by John Krafcik, and defined in 1996 by James Womack and Daniel Jones to consist of five key principles; 'Precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let customer pull value from the producer, and pursue perfection (Levinson, 2013).

Since the 90s, the main approach to create highly efficient & effective processes has been the Lean Production system. The whole idea of Lean Production was to reduce the complexities, which were present in the Computer Integrated Manufacturing era. This integrated manufacturing was too complex to handle the required automation technology.

There are advantages of combining Lean and Industry 4.0 philosophy. Industry 4.0 can be integrated with Lean Production and beyond that improve ICT (information and communication technologies). This benefit accelerates the shift of Industry 4.0 from science to reality. In practice, new solutions must add value to users and must have an acceptable risk and price. There are still some areas where the Lean Production cannot completely fulfill today's requirements. In those areas, the integration of Industry 4.0 solutions comes in play. Even though Industry 4.0 is usually costly, some cost-saving areas still need the newest technologies to operate and improve. One can reduce the risk of integration by applying Industry 4.0 to established Lean Production systems, due to existing advice for the organizational integration. Besides, the Lean Production processes compared to other kinds of organization processes are more transparent, more standardized, and usually reduced to essential work. Therefore, they are less complex and support the implementation of Industry 4.0 solutions (Kolberg & Zuhle, 2015).

There are many use cases where Industry 4.0 can be applied in Lean production. Some of the most common are smart operator, smart product, smart machine, smart planner. Within the methods, by which employees in case of a failure should be notified as soon as possible, the Smart Operator could reduce the time from failure occurrence until failure notification. Equipped with smart watches or similar gadgets, employees receive error messages and their locations close to real-time. In comparison to wide-spread signal lights, recognizing failures would not depend on the location of employees or the error itself anymore. Besides, CPS equipped with proper sensorics recognize failures and automatically trigger fault-repair processes on other CPS. A continuous flow of pieces could be supported by assisting systems for employees based on e.g., augmented reality. Information about cycle times within the visual field of employees supports just-in-time proceeding of goods. In addition, new employees get individualized information about necessary tasks to get along in timed productions. (Kolberg & Zuhle, 2015). In the context of continuous improvement processes, also called Kaizen in Japanese, Smart Products can collect process data for the analysis during and after its production. In contrast to manual data acquisition for value stream mapping, it is possible to gather information individualized per product and production line automatically close to real-time. Firstly, this way of data acquisition is less labor-intensive, and secondly, data is more precise. Technical installations should help employees to avoid mistakes and increase quality. With their computing capacity and connectable sensors, CPS could be integrated fast and flexible in fault-prone processes for supporting. Optically identical components can be identified e.g., via QR codes or RFID (radio-frequency identification). Lean Production's requirement for a flexible, modular and efficient production can be easily achieved by integrating Industry 4.0 into the system. The Lean Production does not support the production of customized single items and aims for a one-piece flow and the highest possible product variety. The Smart Planner could help transform the current system (fixed cycle times and fixed round trips for transporting goods) into a more dynamic production. The new dynamic productions can automatically synchronize with current production programs and improve the transport of goods. With the help of computer integrated systems in working stations, one could get rid of bottlenecks in the production, since CPS could negotiate cycle times and thus find the optimum between the highest possible capacity utilization per working station, allowing a continuous flow of goods. Combining Industry 4.0 with the Lean Production approach could enable Lean Production to be implemented not only in mass and batch production, but also in smaller production systems (Kolberg & Zuhle, 2015).

2.4 Added value of digitalization

Digitalization moved production closer to the consumer because of the increasing demand for customization, resulting in lower transportation costs and faster delivery. With digitalization the manufacturing and maintenance become more proactive, meaning that with the help of constant data streams, machines are more efficient and accurate, predicting and correcting in terms of repair (Mehta & Hamke, 2019).

Based on a survey done by McKinsey in 2016, the manufacturers found the most value in the following five applications:

Digital performance management. Digital performance management requires minimal resources and can serve as the entryway to digital manufacturing. It allows simple, fast and deployable solutions. With such management, the foundation for more advanced Industry 4.0 technologies is created. With the combination of existing lean management processes, digital performance management can build digital capability with data-driven mindsets. Some digital performance management tools being already used help companies increase their OEE (Overall Equipment Effectiveness). Digital dashboards support performance dialogues by achieving as much as a 20 to 50 percent OEE improvement within three months by increasing the engagement of both frontline operators and managers around data. Furthermore, digitized performance data persists beyond the shop-floor whiteboard and supports normalized calculations and reporting, allowing Key Performance Indicators across previously pre-frozen functions, plants, and business units to be shared and benchmarked for consistency and exchange of best practices (McKinsey, 2016).

Predictive maintenance. Due to great improvements in data gathering, machine and deep learning technologies and cloud computing the term predictive maintenance is being redefined. The new version of predictive maintenances is based on integrating diverse data blocks and the use of complex deep learning algorithms such as neural networks. This typically results in an increase (10 to 15 percent) in machine availability and a reduction in maintenance costs – based on the introduction of new predictive maintenance algorithms. The three main areas of predictive maintenance in companies that need to be covered are deep maintenance expertise and knowledge of the respective asset, strong advanced analytics know-how, and the appropriate change management capabilities (McKinsey, 2016).

Yield, energy, and throughput optimization. By integrating the data taken from process control systems with other data, enormous optimizations of company energy, yield and output can be achieved. Mostly supply, demand and cost data are combined with the process data. Manufacturers these days implement a lot of new software and hardware and combine it with plant data to achieve increased efficiency. This data is real-time data and can be extracted anytime. Companies, in addition, must build or source the know-how to create the right algorithms based on the data gathered. Lastly, providing the right implementation support both for an initial pilot, and for scaling the optimizations across the company is crucial to succeed (McKinsey, 2016).

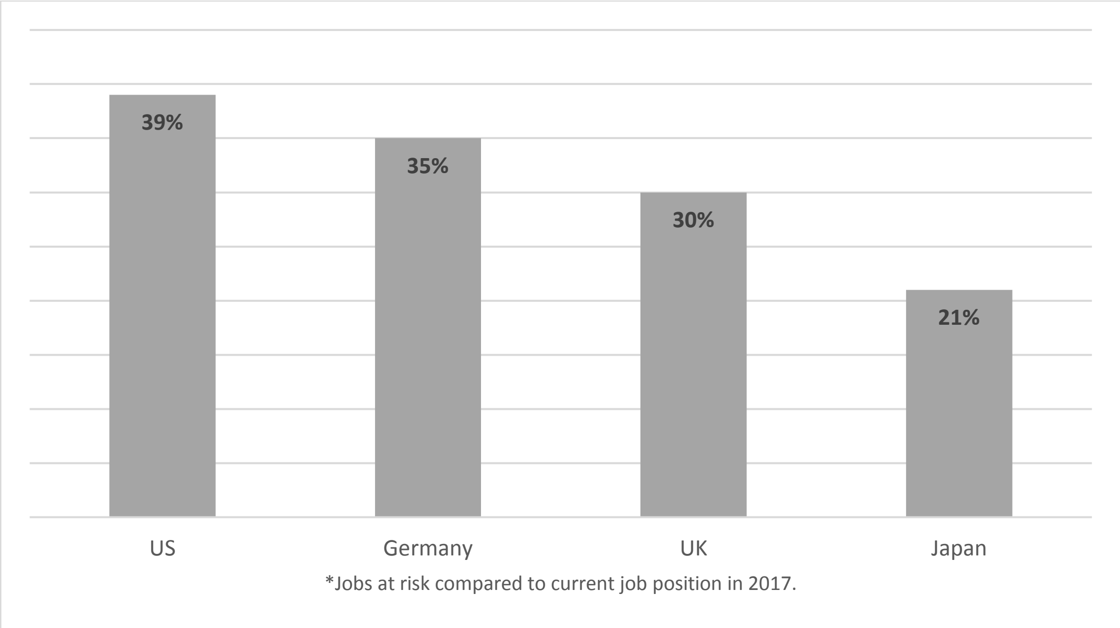
Next-level automation. Currently, there is still a lot of potential in increasing and improving the use of automation in all areas across the business for almost all companies. Especially in the area of manufacturing work, it is expected that the adoption of robotics will grow significantly in the next couple of years. There will be more and more industrial robot implementations due to the decreasing costs of approximately 10 percent p.a. until 2020. The usage potential of robots is also growing. With improvements in sensor technology and artificial intelligence, robots can be used in more complex tasks and processes. Those factors are driving the growing accessibility and potential value of automation. There is still a lot of potential for automation, especially in areas such as demand planning (with use of predictive analytics) and order management (with no-touch order management) in the supply chain process (McKinsey, 2016).

Digital quality management. Companies that are at the beginner phase can obtain essential benefits such as higher efficiency, the ability to track errors, and cost reduction by implementing digital quality management systems. Those can help record and store quality, relevant production, and service information. With the help of new advance sensing technologies like computer vision, robots and wearable gadgets added value in the segment of advanced quality control can be unlocked. To further gain competitive advantage, companies try to upgrade their digital quality management by using advanced algorithms and big data for quality analyses. Semiautomated root cause analysis is one of the main analysis used (McKinsey, 2016).

2.5 Impact of robotization on employees

Contrary to popular belief, automation will not result in a loss of jobs but just a shift in roles. Even though machines are likely to take over most of the repetitive manual tasks, the resultant displacement of workers will also be followed by the emergence of new opportunities in the form of more skilled jobs and better training (Mehta & Hamke, 2019).

Figure 16: Potential job risks in different countries because of automation



Source: Mehta & Hamke (2019)

Figure 16 is based on a PWC study, where they found out that mostly the U.S will have to fire employees replaced by robots. The study also reveals that mostly positions in transport and storage (56%), followed by manufacturing (46%), wholesale and retail (44%) will be replaced (Mehta & Hamke, 2019).

Human Resources 4.0

Implementation of Industry 4.0 technologies brings many changes which disrupted many industries, business and even business functions such as marketing. The Human Resources profession is also beginning to feel the effects of the rapid pace of changes. The concept of HR 4.0 is closely linked to the fourth Industrial Revolution or so-called Industry 4.0. The major transformation of Industry 4.0 does not only change the manufacturing approach but has also affected human resource requirements. Due to the new technology, many previous HR activities are becoming more automated, focusing its operations on strategic problems rather than manual, bureaucratic and repetitive actions. These changes can be seen both in the creation of the new tools and in the new government requirements regarding labor relations (MJV Innovation, 2019).

There are three technological bases that have influenced the future of business, based on the research done in the United Kingdom: artificial intelligence and robots, internet developments and time and space constraints for the acquisition of skills (Störmer, Patscha, Prendergast, & Daheim, 2014). The developments created by Industry 4.0 will not only affect the structure of technology, geopolitics, socioeconomics and the population, but will also lead to the emergence of new business categories and new professions, some of which will also be eliminated. These developments will alter the skills required in both old and new jobs, redefine how and where individuals work, require a new understanding of management and new management regulations. (Bayraktar & Atac, 2018).

Industry 4.0 will shift all steps from production to distribution, from distribution to marketing, and incorporate the organization's radical innovations. At the center of these innovations will be human resources. More agile companies will benefit because they are more adaptable and will surpass their competitors. Human resources will need to redefine their mission, job definition and responsibilities to have agile processes spread throughout the company. (Bayraktar & Atac, 2018).

Strategic perspective

In order to achieve pledge results, the human resources department should cooperate with other units. HR specialist task is to recognize the company's needs from a different perspective. Hence to that they should be informed about all up-to-date developments throughout the company, understand financial data and have a good command of the dynamics in the sector in which the company operates because they should develop applications and projects parallel to these elements that will be needed (MJV Innovation, 2019).

Employment

The presence of Industry 4.0 will change all processes and customer expectations. Technological unemployment will occur with the spread of robots. In the short run, technological developments will particularly alter the workforce structure. In the long run, the labor force will increase in quantity and quality. The mind will be a replacement for muscular power, and we will have to increase the level and quality of educated people. In the long run highly qualified individuals will be employed and will work together in harmony with robots and new technologies (Bayraktar & Atac, 2018).

Reaching the talent

Specialists in human resources will find it difficult to head-hunt for capable staff needed by the digital transformation and Industry 4.0. Human resources management will have to replace the current proactive approach with a talent-oriented, talent-driven proactive approach and start looking for qualified personnel from all over the world. The company's goal is to find the right personnel with the individual skills needed. Such workers will have flexible job opportunities and be able to work in the countries where they are based.

One of the biggest challenges is to find talented people among all the highly qualified workforce. People with talent, experience and skills will be even harder to find. The only way to succeed in this competition is to set up your own talent management system and integrate it into the HR process. Finding next-generation digital capabilities such as Data Scientist, Artificial Intelligence Specialist, or any other specialist will not be easy because these abilities cannot be fully displayed on a CV, LinkedIn or similar. They should start thinking about new hiring methods which will help the company find the right people with all the above-mentioned knowledge for each position (Bayraktar & Atac, 2018).

One of the methods seen today is that more and more recruitments are solved at an early stage with the help of robots, which can easily scan a few hundred application per hour and eliminate inappropriate ones. In the second step, an HR specialist will have applications sorted by parameters which will be set into robots and will be able to start with face-to-face recruiting. Digitalization also brings alternatives to a standard CV, where people could be more creative and for example make five to ten minute long movies, where they can highlight their capabilities, trying to make a good first impression on the recruiter.

Training

One of the most important steps within Industry 4.0 is not only recruiting the right talents but also training the current employees. Most of the companies do not want to fire people, but instead, offer them to be trained to be capable of operating a certain position. People who have been working for a few years or more in the company have already gained some insight knowledge, and it is easier and more affordable to train them. In case that because of new technologies, certain position will be cancelled employees can be relocated and fill other positions. Firing employees will be the last thing done by a company (Bulte, 2018).

There are different scenarios for assessing the development of qualifications and training within Industry 4.0, as three variants appear. Some authors believe that there will be polarization, others expect a general increase in the need for qualifications and training, while others expect a double (academic and professional) professionalism as an increasingly important link between different levels of qualification (Čič & Žižek, 2018). The three scenarios are presented below:

1. Scenario 1: growing gaps. In the scenario, the gap between highly skilled workers and low-skilled workers is widening.

2. Scenario 2: general knowledge upgrade. Under this scenario, a general upgrade of skills and knowledge is expected in line with the new requirements of all employees.

3. Scenario 3: the growing importance of training and qualifications. This scenario emphasizes the importance of training and qualifications for specific professions. This is the link between qualification levels, areas of expertise and abstract and concrete requirements.

Table 2: Knowledge and skills required for activities in your future factory

	Must	Should	Could
Technical Qualifications and Skills	IT knowledge and abilities, Knowledge Management, Computer programming/coding abilities Data and information processing and analytics Statistical knowledge Organizational and processual understanding Ability to interact with modern interfaces (human-robot)	IT knowledge and abilities, Knowledge management, Computer programming/coding abilities Interdisciplinary/generic knowledge about technologies and organizations Specialized knowledge of manufacturing activities and processes Awareness of IT security and data protection	IT knowledge and abilities, Knowledge management, Computer programming/coding abilities Specialized knowledge about technologies Awareness of ergonomics Understanding of legal affairs
Personal Qualifications and Skills	Self and time management Adaptability and ability to change Team working abilities Social skills Communication skills	Trust in new technologies Mindset for continuous improvement and lifelong learning	

Source: Gehrke (2015)

2.6 Industry 4.0 managerial competences

The need for special skills will drive the change in job development in Industry 4.0, which will need more qualified managers. To work with new materials, machinery, and particularly knowledge, the high-tech manufacturing environment will need both skilled managerial labor and production labor with expertise. The need for special skills will drive the change in job development in Industry 4.0, which will require more skilled managers. An article in Economics & Management Innovations (ICEMI) at Volkson Press addressed the following question: “What kind of skills are contemporary managers going to need in Industry 4.0 to overcome new challenges?”

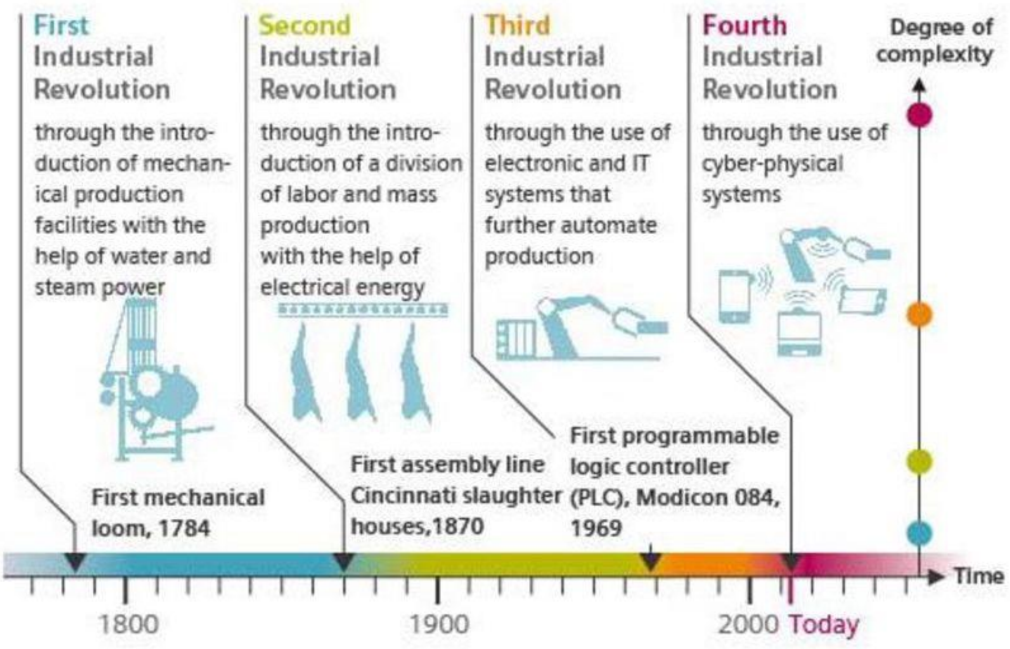
According to the literature, the authors identified three main categories to classify core managerial competencies. First of all, there are technical competencies such as media skills, coding skills, knowledge management and statistical command. Secondly, management skills, including all skills and abilities for general problem solving and decision-making are needed. Some of those are analytical and research skills, conflict and problem-solving skills, as well as creativity. With the right management skills, one should be able to make business decisions and lead subordinates within a company. Thirdly, social competencies include the social values of a person, motivations such as the ability to share knowledge, skills in leadership, ability to function as a team. Social skills are the basis on which expectations for continued interactions with others are developed, and on which people build their own behavioral perceptions. (Katarzyna Grzybowska, 2017).

2.7 Industry 4.0 application challenges

Companies face immense challenges in implementing smart factories, given the large-scale, systemic transformation, the move requires (Sjödin, Parida, Leksell & Popovic, 2018). Industry 4.0 was born in developed countries, where emerging countries may face an important gap for the Industry 4.0 adoption due to the low maturity of prior industrial stages. On the one hand, we still see high uncertainty among manufacturers regarding what implementing Industry 4.0 really requires of them – and many are still struggling to even get started. On the other hand, most technology suppliers have moved relatively fast in adjusting their portfolios towards Industry 4.0 (McKinsey, 2016).

With increased complexity, there are new obstacles in the process of implementing/applicating Industry 4.0/smart factories. In Figure 17, we can see the estimated complexities of each Industrial Revolution.

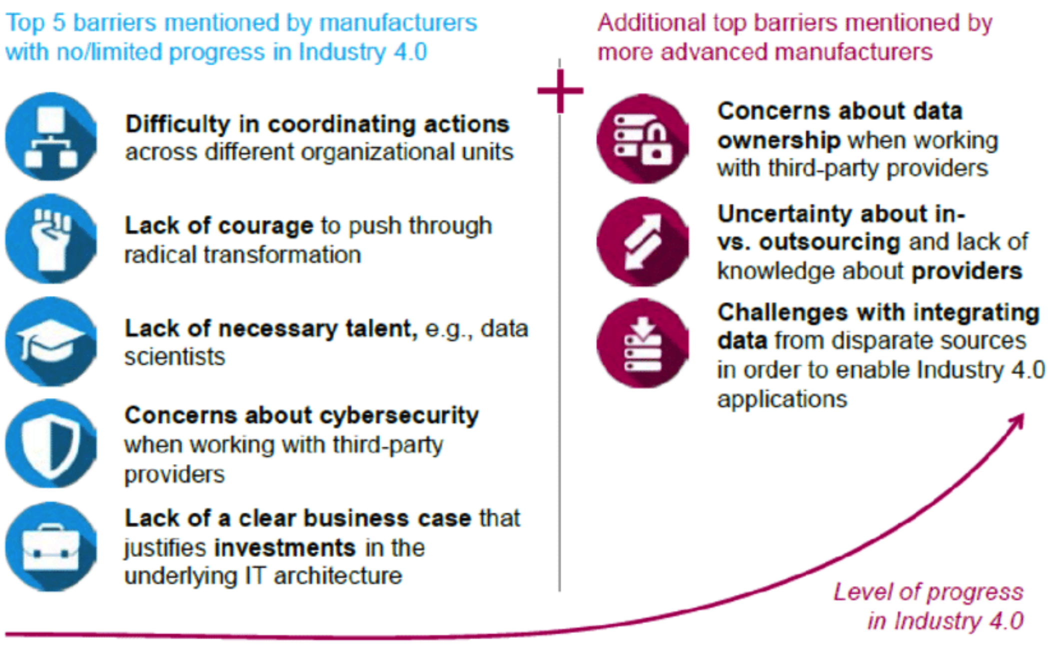
Figure 17: Complexity of Industrial Revolutions



Source: EDN (2013)

Most companies face challenges such as security, capital, employment and privacy, when trying to implement smart factories/Industry 4.0. In Figure 18, the results of a global survey done by McKinsey are presented on application barriers of Industry 4.0.

Figure 18: Barriers in different levels of progress in Industry 4.0



Source: McKinsey (2016)

First difficulties appear in the coordination of different departments across different organizational units. Companies still have problems breaking the still very strongly isolated work between, among others, manufacturing, research and development, sales, IT, and finance departments. These walls between functional departments make it difficult to coordinate and implement Industry 4.0 strategies and projects across the entire organization. Because there is a lack of courage and will to push through some radical transformations, many manufacturers do not achieve the kind of technical and organizational restructuring that Industry 4.0 requires. Companies may also not have good data scientists and other key employees. Mostly manufacturing companies experience problems with Industry 4.0 applications, because they do not have workers with necessary knowledge and skills. When combined with concerns about working with third-party providers that have the knowledge, it paralyzes the companies. Mostly because they have concerns about cybersecurity when working with third-party providers and data sharing. New Industry 4.0 technologies often require the involvement of external companies that have the needed software and knowledge. Companies, therefore, struggle and are still hesitant to share their own data with them, because of the IT security concerns. The last of the barriers that prevents manufacturers' progress in Industry 4.0 is the lack of clear business cases that justify investments in the underlying IT architecture. Many companies still do not have business cases which would sufficiently justify larger investments. Still, without overarching investments in data and systems, architecture companies will not be able to implement Industry 4.0 applications across the organization (McKinsey, 2016).

Organizations that have already made some progress in Industry 4.0 have three additional barriers that mostly prevent them from achieving their next milestones. Those are:

- Additional concerns about data ownership, whenever they outsource their activities or sharing their data.
- Ownership of their data when working with external partners or using their software.
- Original Equipment Manufacturing contracts (OEM) are often formulated in a way where data ownerships are already way too limited.

Uncertainty about which Industry 4.0 applications to tackle internally and which to outsource to third-party providers as well as the lack of knowledge about suitable providers can slow down the Industry 4.0 implementation process. Companies these days often cannot decide which processes and activities should be handled inhouse and which ones they should outsource. Since companies could save time and money by letting third-party companies handle a part of their processes. Still, many manufacturers do not find suitable providers of services, which could take over some of their in-house activities.

Challenges appear with integrating data from disparate sources to enable Industry 4.0 applications. Most Industry 4.0 applications are built on data from diverse sources. Combining this data together in a useful whole is crucial to make Industry 4.0 work, but data integration and interpretation can be a difficult task (McKinsey, 2016).

With digitalization, companies will face risks in the field of IT. This might result in security breaches, data leaks and cyber theft/hacks. To prevent such attacks, a lot of money needs to be invested into security. Overall, the whole transformation as such requires a huge investment since the new technologies and machines are quite expensive. Large investments are needed if enterprises are to make the move to Industry 4.0; these are projected to be €40 billion annually until 2020 for Germany alone (perhaps as much as €140 billion annually in Europe). These investments can be particularly daunting for small and medium-sized enterprises (SMEs) which fear the transition to digital because they cannot assess how it will affect their value chains. So far take up has been cautious: even in Germany (a leader in manufacturing), only an estimated one in five companies uses interconnected IT systems to control its production processes, though almost half intend to do so. Some critics say that systems are too expensive, too unreliable and oversized, and that largely equipment producers rather than customer demand are driving the Industry 4.0 approach (European Union, 2015).

Difficulties in creating a competitive advantage within Industry 4.0

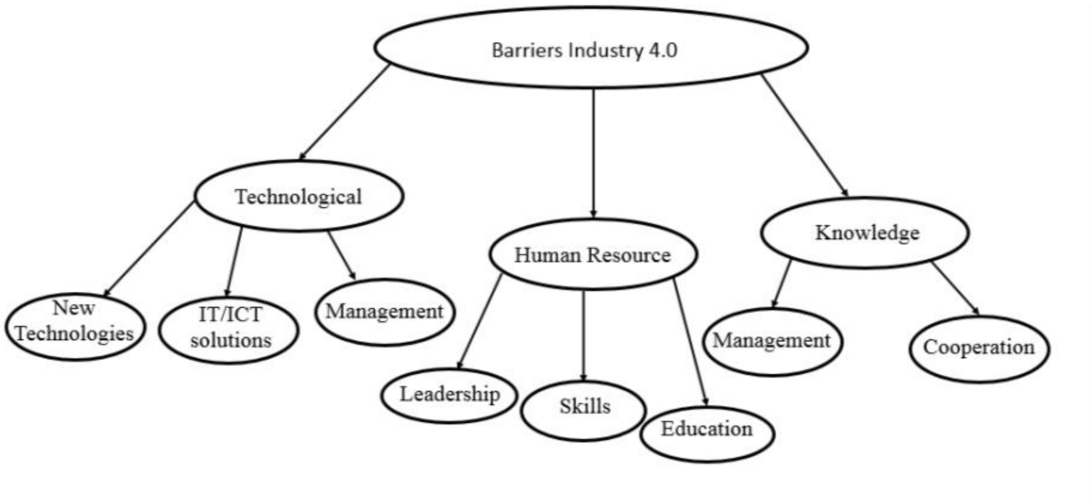
Barriers do not only appear when it comes to implementing Industry 4.0 in a company, but they reappear when companies develop strategies for competitive advantage based on Industry 4.0. A research presented in the 10th Conference on Management of Organization's Development, published by Springer came up with interesting results. The main goal of their paper was to identify and map the key barriers and potential sources of failure in processes of building competitive advantage of enterprises operating in the age of Industry 4.0. The findings from an International experience are presented below (Bielawska & Staniec, 2020).

Their detailed and generalized analyses showed that there are relatively more articles and studied cases about Industry 4.0 in general, rather than articles about the barriers that arise when trying to build competitive advantage in the era of Industry 4.0. Because Industry 4.0 is often linked to new IT technologies, IoT, new ways of production and transport mainly in the digital environment, companies will have to learn to function and communicate on other levels. Organizations will have to restructure to be able to work in a virtual/cyber environment. To meet this challenge, they unfortunately must undergo changes related to:

- technologies they use,
- their organizational solutions,
- relationships they use and develop and their social competencies.

The study separated the "Determinants of achieving competitive advantage in the age of Industry 4.0" into three groups: Technological, Knowledge and Human Resource (HR). They identified 64 barriers across those three sections during the analysis. The areas of prevailing obstacles are graphically presented below (Bielawska & Staniec, 2020).

Figure 19: Barriers of creating competitive advantage based on areas



Source: Bielawska & Staniec *(2020)*

In the <u>HR group,</u> the main barriers that appeared were related to the areas of "Leadership" as well as "Skills" and "Education" that were not adjusted to the requirements of Industry 4.0. Other types of barriers were also noticed in the group. The biggest barrier in this HR group was Leadership, where incorrect management of employees presented the main problem. They do not have the talented leaders, which are needed in this era of digital transformation to manage the employees correctly. The same problem was found in as many as 83% of the companies examined in 2017 by Deloitte and 69% respondents of McKinsey. It seems to be the strategic problem from which others stem. There are especially problems with hiring the right workforce with the skill sets needed for the future of work. Workers will have to undergo changes by learning new skills and acquiring new knowledge. Companies need to educate them for new roles introduced through digital transformation (Bielawska & Staniec, 2020).

In the <u>Knowledge group,</u> the prevailing barriers were related to the areas of "Management" and "Cooperation" that were unadjusted to the requirements of Industry 4.0. Barriers related to the areas of "other type" were also noticed. The problems related to Management were in planning and organizing as well as in innovativeness. Industry 4.0 will affect organizational structures and their employees in ways that are hard to predict. Therefore, companies need to be able to plan and address the impacts the new Industrial Revolution brings along accordingly. Companies fail to predict the future changes because they are usually focused on past accomplishments, while not keeping track of the current and future changes within the market. When it comes to innovativeness, organizations are not ready to fully harness the opportunities associated with Industry 4.0. Many executives continue to focus on traditional business operations, as opposed to focusing on opportunities to create new value for their direct and indirect stakeholders. As for the cooperation aspect interdependence causes problems. The growth of global business networks changes the risk landscape and makes companies more vulnerable to external shocks. Companies are becoming more and more interdependent. Companies have become very selective when it comes to choosing the right partner to work with, since there are many barriers present when extracting value from external partners. Concerns about data privacy and security are the biggest obstacles preventing partnerships (Bielawska & Staniec, 2020).

In the Technological group, the biggest barriers appeared in the areas related to the abilities of effective implementing "New Technologies" and "IT/ICT solutions". The next larger problems appeared in the area of "Management". Other barriers were also noticed. In the IT and ICT sector the main challenges were:

- Creating a network across multiple platforms.
- Lack of scaled analytical platforms with advance functions.
- Lack of adopting specific Digital Manufacturing rollout-relevant solutions company-wide.

When it comes to Technological management knowledge, time and leadership are the main barriers. Agility is the new currency of business (Bielawska & Staniec, 2020).

3 SMART FACTORIES

A Smart Factory can be defined as an interconnected and flexible manufacturing system that can quickly adapt to new demands/changes by using a continuous stream of data from connected operations and production systems. According to some analysts, smart factories will drive the new Industrial Revolution that has the potential to seriously disrupt incumbent companies (MacDougall, 2014). A Smart Factory is the vision of a production environment in which production facilities and logistics systems are organized without human intervention (Finus, 2019).

To have a better understanding of what Smart Factory means and how it differs from a traditional one, we will provide a comparison between these two. In Table 3, we see that a Smart Factory has more automated jobs which are related to having robots instead of labor workers. This leads a Smart Factory to higher productivity, and it has an impact on quality. We know that robots can significantly improve product quality because applications are performed with precision and superior repeatability on every job. This level of reliability can be difficult to accomplish in a traditional way with only humans working (Calderone, 2016). A very similar case is also with productivity which can increase only when robots are applied to tasks that they perform more efficiently than humans (International Federation of Robotics, 2017). On the other hand, robots can keep workers safe in extreme environments, and this is only one of many reasons why they are an essential part of our everyday life (Robotics Business Review, 2019). As robot production has increased, the costs have gone down, and over the past 30 years, the average robot price has fallen by half in real terms. This means a quick return on investment (ROI) which outweighs the cost. All the above-mentioned advantages are only a few among many others, but each of them reduces production cost (Tilley, 2017).

Table 3: Comparison of traditional vs Smart Factory

Traditional Factory	Smart Factory
• Lower productivity • More manual jobs • Lower quality • Less safe working conditions • Less demanding jobs • Greater environmental impact • Higher production costs	• More automated jobs • Higher productivity • Higher quality • More demanding jobs/better paid • Safer working environment • Higher efficiency/effectiveness • Lower production costs • Flexible manufacturing

Source: Fakulteta za strojništvo (2019)

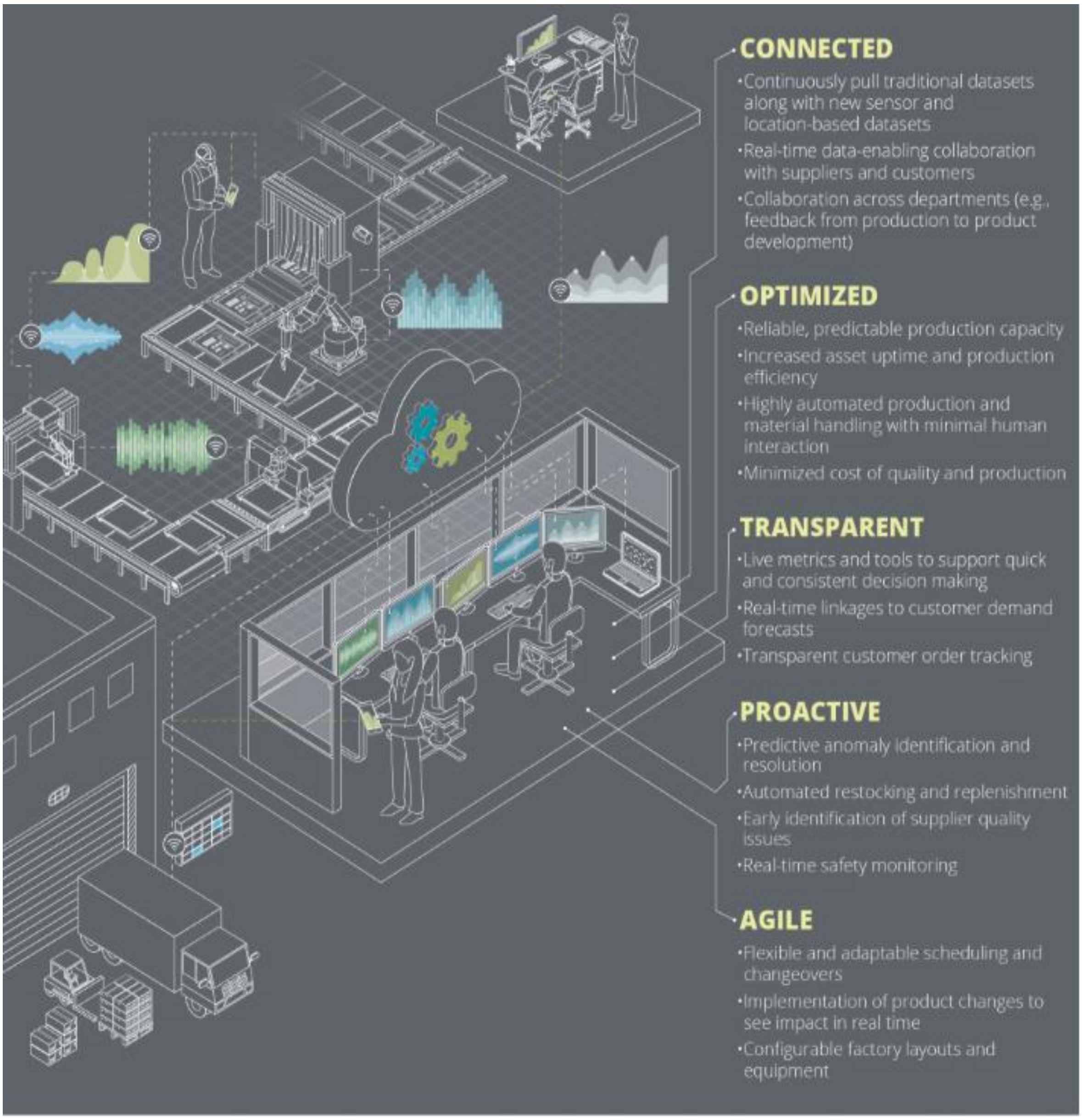
Smart Factories or in other words intelligent factories are based on cyber-physical systems that communicate with each other using the Internet of Things and Services. A true Smart Factory can integrate data from system-wide physical, operational, and human assets to drive manufacturing, maintenance, inventory tracking, and digitalization of operations through the digital twin, and other types of activities across the entire manufacturing network. This can help or lead to more efficient and agile systems, less production downtime, and a greater ability to predict and adjust to changes. It can also possibly lead to better positioning in the competitive marketplace (Burke, Laaper, Mussomeli, Hartigan & Sniderman, 2017).

To have all above-mentioned benefits we can say that the most important process is communication or rather exchange of data between the product and the production line. This technology enables us a much more efficient connection of the supply chain and better organization (Finus, 2019). Product's path through the individual manufacturing steps is written on an RFID chip, and it needs to be written in machine-readable form. RFID is only one of many other technologies, which can be used to increase the efficiency of a production line.

Smart Factory is the core element of Industry 4.0. To have effective communication between different parts, we need to equip tools, products and plant technology with computer power (sensors). This is the only way the data can be captured, processed and forwarded. Smart Factories use industrial Internet and the cloud which enables connectivity not only with real worlds but also with virtual ones. This results in the seamless integration of cyber-physical systems on all levels, allowing the whole production process to be monitored. Another advantage of Smart Factories is minimized downtime because systems allow devices to diagnose problems all the time and provide instant feedback. This means that machines can predict potential faults and provide the required feedback information for swift repairs, resulting in cost savings and reduced downtime (Harting, 2019).

It is important to note, nevertheless, that each Smart Factory will contain major features like connectivity, optimization, transparency and agility. However, each manufacturer will prioritize the various areas and features most relevant for their specific needs. From Figure 20, we can see five key characteristics of a Smart Factory.

Figure 20: Key characteristics of a Smart Factory



Source: Deloitte (2018b)

As we have already mentioned, connectivity is one of the most important characteristics of the Smart Factory, or we can say that it is the most crucial source of value. Connectivity enables us to generate data necessary to make real-time decisions.

After we have established connectivity, we need to process captured data and optimize the process. With an optimized Smart Factory, we are able to execute exact operations with almost no or minimal manual intervention, with the execution being highly reliable. With improved tracking and scheduling, automated workflows, synchronization of assets, and optimized energy consumption, Smart Factory enables increased yield, uptime, quality, and reduced cost and waste (Manganello, 2019).

The data captured needs to be transparent. With the help of real-time data visualizations, one can transform the collected data from different processes or smart products and transform the information into useful and actionable insights. With transparency, we can enable greater visibility across different departments and ensure that the organization can make accurate and faster decisions. Such transparency can be achieved with role-based views, real-time alerts and notifications, and real-time tracking and monitoring (Burke, Laaper, Mussomeli, Hartigan & Sniderman, 2017).

If we want the employees and systems to anticipate and act before issues or challenges arise, we need a proactive system. We can include this feature in identifying anomalies, restocking and replenishing inventory, identifying and predictively addressing quality issues, and monitoring safe and maintenance concerns. This feature can improve uptime, yield, and quality, and prevent safety issues. The last key characteristic is agile flexibility, which allows Smart Factories to adapt to schedule and product changes with minimal intervention. Agility can also increase factory uptime and yield by minimizing changeovers due to scheduling or product change and enables flexible scheduling (Burke, Laaper, Mussomeli, Hartigan & Sniderman, 2017).

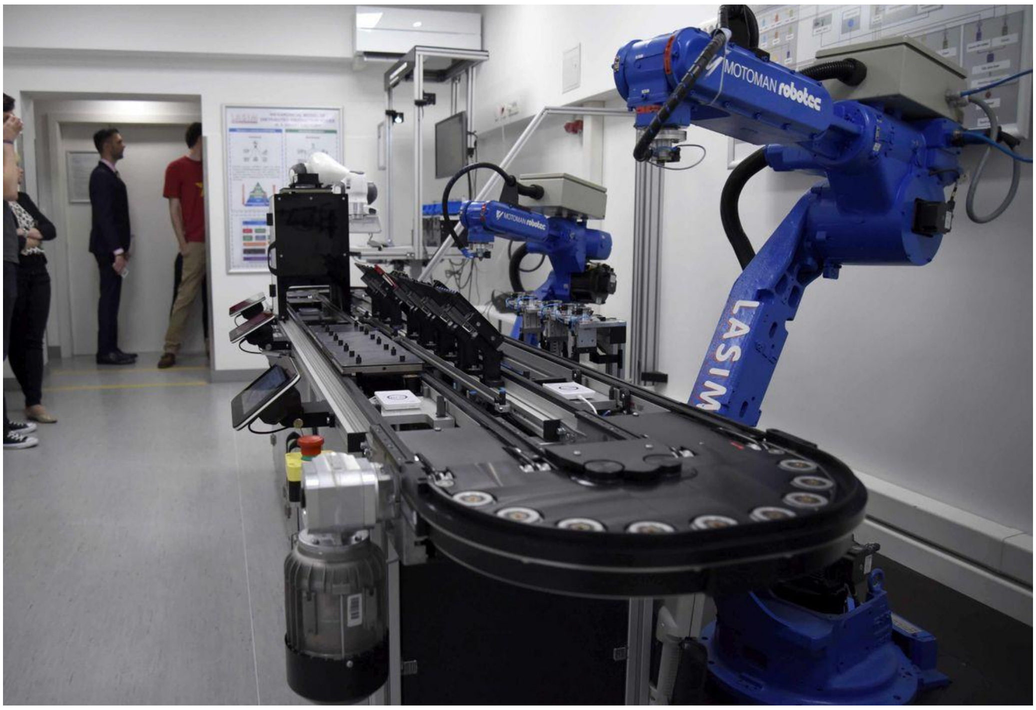
3.1 First Slovenian Smart Factory demo center

In 2019 the first Smart Factory demo center in Slovenia was opened. The project was held by the Faculty of Mechanical Engineering in Ljubljana with the help of GOSTOP program, which is part of S4 (the biggest program for the development of smart factories in Slovenia). The ideology behind this project is similar to that in program S4, which is to show innovative usage, implementation of components from Industry 4.0 and bringing the concept of Smart Factory into real industrial space (Fakulteta za strojništvo, 2019).

If Slovenia wants to be more competitive on the market, companies should start implementing digitalization in all processes. This project was successfully transformed not only to the real laboratory space but also into the real industrial space. In comparison to the classic factory, the smart ones are more efficient, intelligent, flexible, agile and autonomous. This demo center was built on a concept of distributed systems, and it includes more important technologies, which are needed for operating a Smart Factory (Fakulteta za strojništvo, 2019).

The core of a Smart Factory is the global digital twin and global digital agent or with other words artificial intelligence supported with machine vision. Each process has its own digital twin and one or more digital agents, which with the help of artificial intelligence, operate processes and solve local basic problems on their own. It is essential that all operations and activities are visualized and transparent. With RFID technology, they enable the tracking of each process and communication among objects and subjects of a Smart Factory (Fakulteta za strojništvo, 2019).

Figure 21: The Smart Factory at FS



Source: Cerar (2019)

Besides all the robotized stations in the demo center, also a smart manual workplace is included. Here they can demonstrate different technologies of a Smart Factory such as virtual and augmented reality, digitalization, transparency of instructions for assembly operations, adaptability of mounting points, ergonomics of workplace and similar. A Smart Factory in a demo space enables not only fully flexible and agile, but also autonomous planning and optimization of the working plan and working process (Petrov, 2019).

3.2 Why Smart Factory?

In 2018 the Smart Factory market (components) was valued at USD 230.99 billion, and it is expected to reach around USD 390 billion by 2024 (Yahoo Money, 2020). This is only one of the reasons why to smart manufacture and why to adopt it now.

Based on the research provided by Freedom, we can say that 86% of executives believe that digital transformation is critical for growth and competitiveness. In addition, they said that 72% of companies plan to increase their IoT spending over the next three years. As we know, Smart Factories can also contribute to having better maintenance strategy, otherwise it can reduce production up to 20%. With unplanned downtime, this can each year cost industrial manufacturers around USD 50 billion. The above-mentioned facts are only a few out of many, which stress the necessity of implementing new technologies. Companies should start implementing smart components into standard manufacturing and transform it into a Smart Factory (Freedom, 2018).

4 INDUSTRY 4.0 IN SLOVENIA

Industry 4.0 was publicly introduced for the first time in 2011 by a group of representatives from different fields under an initiative to enhance German competitiveness in manufacture industry. Later, the term was spread all over the world, including Slovenia (Luenendonk, 2017). Manufacturing industry is the one of the prevailing ones in Slovenia. According to the data, we exported for around € 6.3 billion in 2018. This represents around one-fifth of all Slovenian exports (€ 30.9 billion) in 2018, with Germany as Slovenian biggest exporter. Based on that information, we know that if Slovenia still wants to have Germany as the biggest exporter, they need to follow their trends. Slovenian companies will need support on the country level for faster and better implementation of new technologies.

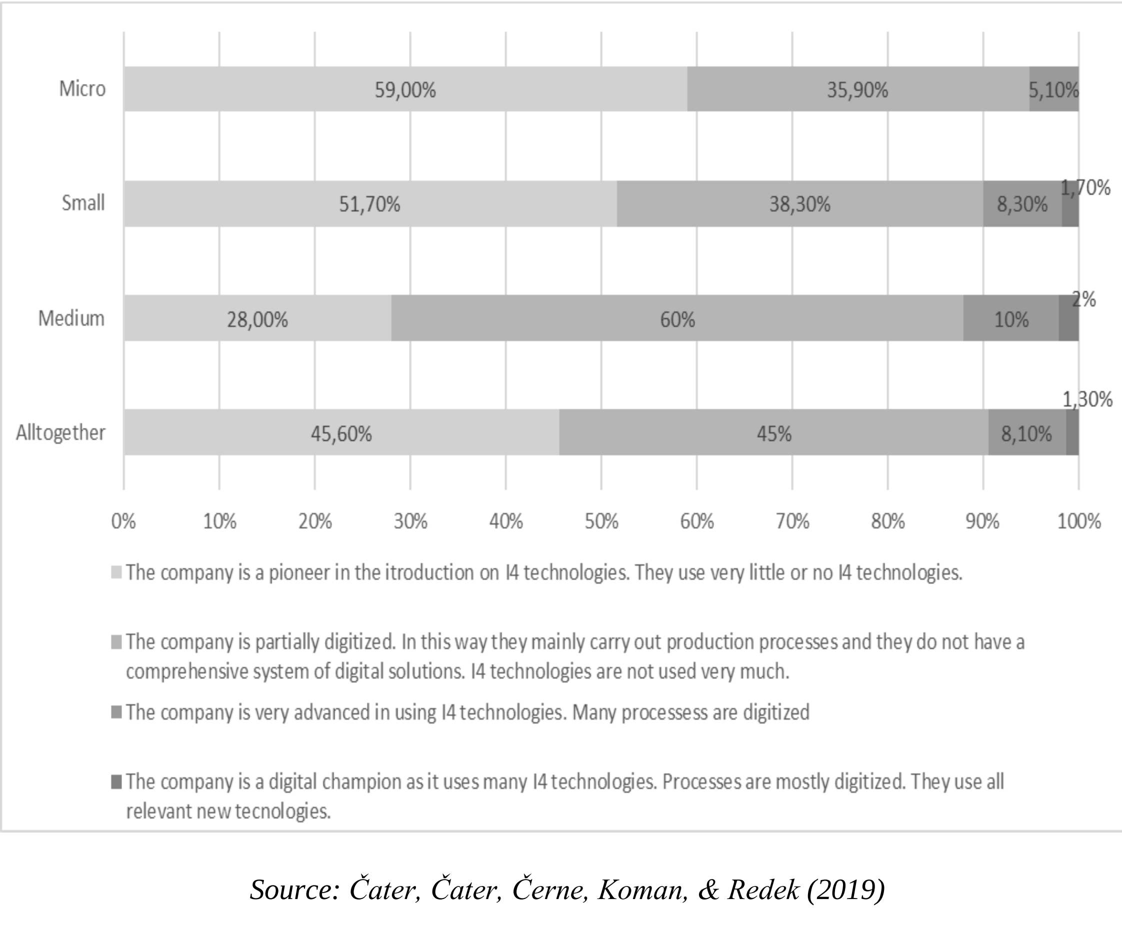
Even though everything started with German competitiveness, other companies which develop components and technologies for Industry 4.0 that are present all around the world, are now competitive or even better from pioneers. Many of them are also from Slovenia and they are offering world-known solutions which are adaptable for huge players (for example: Kopa, Hidria, MIT informatika, RoboticsX, etc.). This proves that we are aware of Industry 4.0 in Slovenia and that we have people who can provide solutions to our domestic companies. Technology developed on the Slovenian market can improve the whole working process or productivity indicators, which are the most preferable by buyers (Varga, 2018).

With a higher level of Industry 4.0, we are also facing more innovative solutions, which helps to improve productivity indicators and facilitate production or service. But many companies started the implementation of Industry 4.0 from the wrong side, because they thought that the productivity would increase with buying new machinery and technology, resulting in investing a lot of money, with improvements that do not satisfy their expectation. Key to success in Industry 4.0 is to know and understand deeply how to use all the data gathered with new machinery and technology to improve specific workstations or the process. Not everything is about new technologies, rather the most important part in Industry 4.0 is in the hands of employees. The most important thing is how the knowledge is transmitted and how to use useful cases which facilitate the learning of new employees or the workplace. One of the advantages is also that Slovenia started implementing technologies of Industry 4.0 at early stages, which puts Slovenia in a leading position (Varga, 2018).

Based on a research from various Slovene economists, mostly small and middle companies lag behind with new technologies of Industry 4.0. The main perceived barriers in those companies are the lack of qualified staff, the reasons related to the lack of knowledge and finances, inadequate infrastructure, machinery and tools (Čater, Čater, Černe, Koman, & Redek, 2019).

The research gives us an insight into the current situation of digitalization or usage of Industry 4.0 technology among different Slovenian companies. The results show that 45,6% of all interviewed companies consider themselves as beginners who use almost no digitalization or new technologies of Industry 4.0. Partially digitalized with 45% are mostly manufacturing companies. Those companies do not have comprehensive solutions, and the usage of new technologies is very low. With 7% we have companies which are very advanced in the usage of new technologies and with 1,3% we have only two companies which marked themselves as digital champions. From Figure 22, we can see that the size of the company has a significant impact on the level of digitalization (Čater, Čater, Černe, Koman, & Redek, 2019).

Figure 22: The intensity of the introduction of new technologies in the MMPS

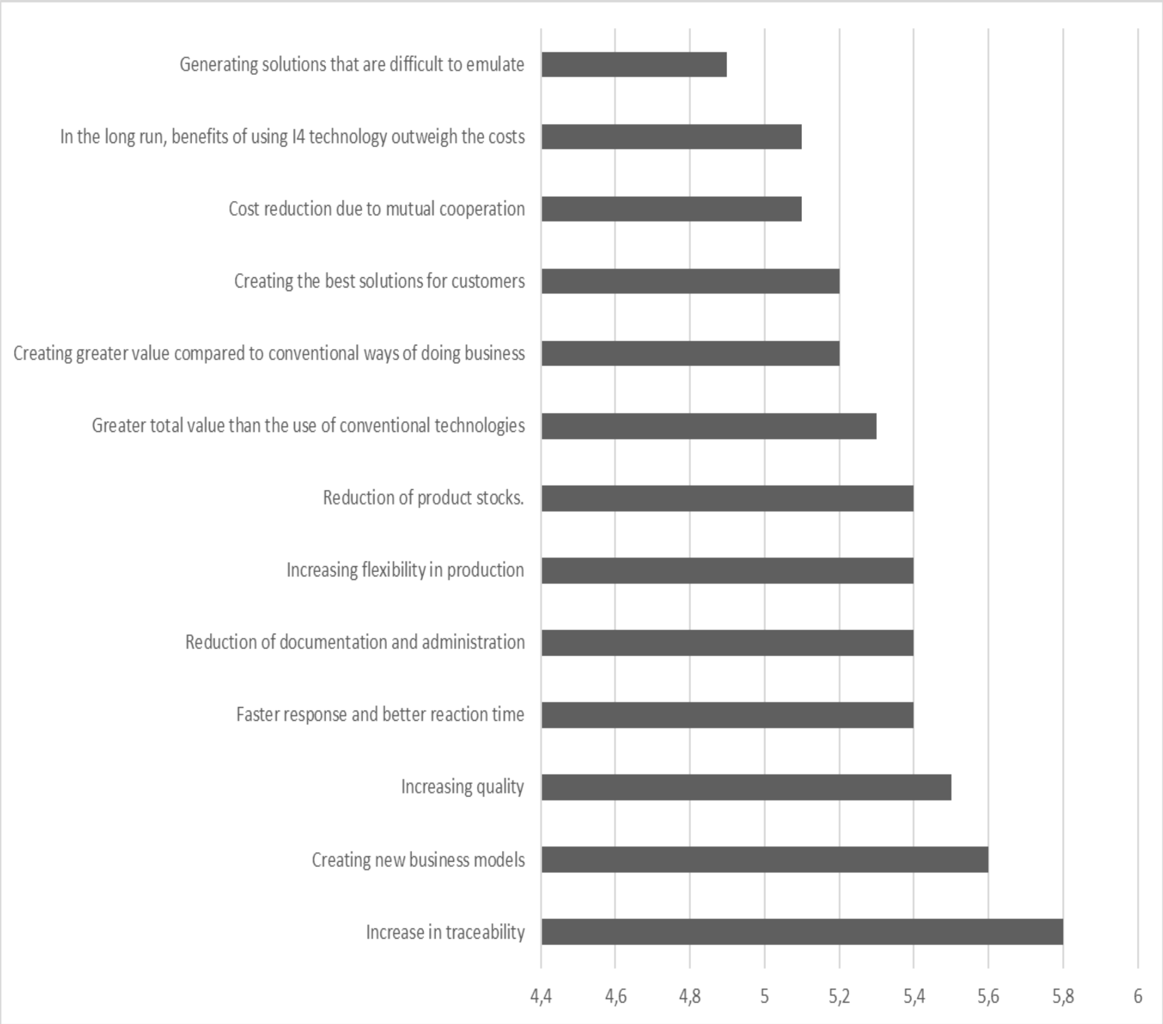


Source: Čater, Čater, Černe, Koman, & Redek (2019)

The research shows that the most common technology is cloud computing and smart devices. Internet of Things, robots and automatized manufacturing are used by one third of all companies. All stated technologies are considered to be used by 40-50% of medium sized companies and at least 10-20% of micro companies. Companies regardless of size expect

(Figure 23) benefits mainly due to increased traceability, creation of new business models, increased quality, faster response, greater flexibility, less administrative and other burdens and due to the benefits arising from the ability to adapt the product to customer needs (Čater, Čater, Černe, Koman, & Redek, 2019).

Figure 23: Assessment of the impact of the introduction of I4 technologies in companies through different channels (ocean on a scale of 1-7: 1 = strongly disagree, 7 = strongly agree)



Source: Čater, Čater, Černe, Koman, & Redek (2019)

Slovenia, with the size and all the industry it has, can be a very good prototype (IoT) country. Companies can develop a lot of new technologies for Industry 4.0, which can be easily tested as pilot projects and later on implemented in other countries (Varga, 2018).

4.1 The role and importance of the government

In the future, governments will play a huge part in developing industries. In many different areas, European companies are lagging behind the competitive ones from the USA. The government's role is to act as fast as possible to provide the necessary strategy and appropriate structure of education, research and development, which will help achieve government level goals and also the global ones. Companies need to be encouraged to invest more money in this process. This can be done with tax deductions or with any other similar measure (Bloching et al., 2015).

In 2010 Slovenia made a very brave step with opening and supporting the development of competence centers for implementing IoT into the industry, providing co-financing of this program (EU-Skladi, 2017).

The country must provide the following conditions to maximize the deployment of Industry 4.0 (EU-Skladi, 2017):

1. Innovative and sustainable procurement.
2. Tax incentives for successful R&D companies.
3. Economic diplomacy and promotion. Measures in the field of international economic cooperation will be organized with the assistance of interstate commissions.
4. Effective judicial system.

As part of its promotion of the digital economy, the EU supported an action from the year 2008 to 2014 that focused on the smart use of Information and communications technology and the integration of Small and Medium-sized Enterprises into digital value chains, with a particular focus on global markets. From 2014-20, the Horizon 2020 research program's industrial leadership pillar will provide almost €80 billion for research and innovation, including support for developing key enabling technologies. The research program will also finance prototypes and demonstration projects. Factories of the Future is a public-private partnership (PPP), launched initially under the earlier Seventh Framework Programme but continuing under Horizon 2020, that centers on advanced, smart, digital, collaborative, human-centered and customer-focused manufacturing (indicative budget €1.5 billion). Another PPP, Sustainable process industry through resource efficiency (SPIRE) has a budget of €0.9 billion. Still ongoing is the Seventh Framework initiative ICT Innovation for Manufacturing SMEs (I4MS) which aimed to help SMEs and mid-cap manufacturing companies master the digital transformation in areas such as cloud computing, robotics and simulation (€77 million). Besides, at least €100 billion from the European Structural and Investment Funds (ESIF) are available to the Member States to make investments in innovation, in line with the concept of 'smart specializations' which encourages regions to concentrate on their comparative advantages and to create pan-European value changes (European Union, 2015).

4.2 The role and importance of the company

Companies have many business opportunities from digital transformations. However, it is important to know that companies need to be prepared for huge changes and see those changes as business opportunities and not as a threat. The top management team needs to focus the company's strategy on delivering a higher level of digital maturity in business. The whole company needs to be prepared to take advantage of new opportunities, which are brought by new technologies. Experts should encourage the development of digital culture in companies, and they should be open to new things in digitalization of processes. Technologists should be included in the process of digitalization. Many times, those people are educated for maintenance and for improvement of already established systems, but they should get a chance to see new opportunities, which can be brought by Industry 4.0. Buyers and suppliers will also play an important part; therefore, it is important that they are informed about the development of digitalization (Bloching et al., 2015).

Employees must not be forgotten in the whole process, since many companies think that if they buy new machinery and technology that their productivity will rise. The most important part in digitalization is to educate people to know how to use all provided technology and how to make use of all the data gathered through those technologies. When a company deeply understands the importance of transparency of the data, they can start improving their processes throughout the company, and this will lead to higher productivity, which will help them to be more competitive on the market (Varga, 2018).

4.3 How the concept of Industry 4.0 is already manifested in the Slovenian industry

Many Slovenian companies have already found some solutions to their core business with the help of digitalization and robotization. This helped them to improve their process, which made them more valued and competitive on the market. Some of them are listed below (Planina, 2015):

- Krka,
- Gorenje,
- Kolektor,
- UKC Ljubljana,
- Danfoss,
- Lek,

- Pošta Slovenije.

From the list above, we can see that Industry 4.0 is present in different industries from pharmaceutical to automotive industry. To understand better how and where Industry 4.0 can be implemented, we want to describe three companies, on which our research of the master thesis will be based on.

Company A

Company A was established in 1933 in Denmark. The company manufactures products and provides services used in cooling food, air conditioning, heating buildings, gas compressors and so on. The company currently employs around 28,000 people worldwide.

Since 1995 they have been present in Slovenia - Ljubljana. Company A is presented as a business and technological center for solutions on regulations of heating and cooling transfer systems. On this location, they have around 500 employees. Their strategies and goals strive to satisfy customers, employees, owners and suppliers. The company also offers a comprehensive range of products for the Slovenian market, and it belongs to the world's leading companies.

Products developed and manufactured in Company A:

- Heat exchangers,
- balancing valves,
- temperature regulators without auxiliary energy,
- electric regulation valves and
- pressure and flow regulators without auxiliary energy.

Company B

Company B is a Slovenian pharmaceutical company and is a part of a bigger European pharmaceutical company. The company is people-centered and future-oriented. It presents an important part of an international pharmaceutical company. To have better in-depth knowledge of the company, we should know that Company B was officially founded in 1946. With new investments, the company grew rapidly, the number of employees increased, and their average level of education rose. But a milestone year was 2002 when they became part of the global group.

They are not only a manufacturer but also a developer of market effective, safe and high-quality medicines and active pharmaceutical ingredients. Today they are present in four locations in Slovenia and have in total around 3400 employees. Each location is specialized differently. But if we look into the headquarters located in Ljubljana, we can say that with more than 2070 employees they are manufacturing two different categories of products – solids and aseptics. Both together represent more than 3500 finished products which are present in more than 100 markets. Their whole strategy and mission are focused on patients.

Company C

Company C is a global supplier, which has traditional highly specialized industrial production. With more than 55 years of history, they have become one of the leading providers of commutators on a global level. In their processes of diversification and globalization, they also added programs outside of the automotive industry and expanded their business units on other continents. Today the whole company has around 5500 employees, and it is divided into three divisions: Components and Systems for mobility, Power engineering and Engineering and technology systems. Nowadays, they put a lot of effort into the fourth division, named Digital. Their mission is to produce high-quality solutions that support the competitiveness of the production processes of their customers (Company C, 2019). Their competitive advantages are achieved through investing in innovations, usage of most advanced software, the knowledge of employees and the usage of most powerful and precise machines.

Table 4: Comparison of main factors between the three companies

	Company A	Company B	Company C
Industry	Energy-efficient solutions	Pharmaceutical	Highly specialized industrial production
Number of employees	476	3800	4900
Income	141mil	1220mil	197mil

Source: Dun & Bradstreet (2019)

4.4 Slovenian strategy of smart specialization S4

Slovenian strategy of smart specialization is a strategy which was approved by the Slovenian government. Slovenian strategy of smart specialization is called S4. This strategy is a joint of economy, civil society and research organizations. It presents us with a platform for investing in the development areas where Slovenia has a large mass of knowledge, competences and capacities. Those are the areas in which we have the opportunity to position ourselves on the world markets and become widely recognized. S4 will help to transform Slovenia from being a follower to a co-creator of global trends (EU-Skladi**,** 2017).

This strategy wants to increase the competitiveness of the economy with the help of enhancing its innovation capability, enabling the growth of new businesses or industries and creating industry diversification. The strategy of smart specialization includes a wide spectrum of different areas, for example, smart homes, tourism, health, and similar. But the main goal of this master thesis is focused on the industry. This is the reason why we will be focused more on what this strategy can bring to the Slovenian industry (EU-Skladi, 2017).

Main goals of future factories which are presented in the Slovenian strategy of smart specialization are (EU-Skladi, 2017):

- A complete restructuring of toolmaking with a 25% increase in value-added per employee, which would be on average € 45,000 per employee by 2023.
- Increase the level of digitalization. This would be done through robotization and automatization of production. In Slovenia, only automotive companies are comparable to European companies by the level of robotization. This industry will be focused on the increase of automatization while other industries should increase the level of robotization by 50%. This will increase the current 48 robots to 72 robots per 10,000 employees.
- Increase export of systems and equipment for automatization of industrial systems. The increase should be around 25% by 2023.

4.5 Future usage of Industry 4.0 in Slovenian industries

The European Commission warns their members every year how important Industrial Revolution is for creating new job opportunities and the increase of economy. Therefore, The Chamber of Commerce (Gospodarska Zbornica Slovenije) started a project for achieving new goals of industrial rebirth in Slovenia with the establishment of a strategic group named - Slovenia 5.0. The main purpose of this group is to inform the Slovenian public about the importance of Slovenian industry and the need for quality industrial development.

The strategic group will act as an effective communication and content platform of GZS, which will promote its optimal development based on the comparative advantages of Slovenian industry and based on smart specialization. It will contribute by raising the value-added in the strongest Slovenian industries with two percentage points a year. And at the same time, it will aim to contribute to the continued growth of jobs in harmony with European industrial revival policy (Gospodarska zbornica Slovenije, 2015).

In the document where they want to provide optimal development of industry and economy in Slovenia by 2030, they outline the future path of our industry. The future goals of the Slovenian industry are (Gospodarska zbornica Slovenija, 2015):

- Increase of added value in most powerful industrial areas by 2020 (pharmaceutical, chemistry, electric appliances, plastic and rubber) on 80% of the average value in the EU.

- Increase of average added value on an employee from 39.500 € to 43.500 € by 2020.
- Increase the number of patents from 13 to 20 by 2020.

Slovenia can achieve those goals with the following steps (Gospodarska zbornica Slovenija, 2015):

- Smart specialization (networking into value chains, creating hubs for innovative solutions).
- Industrial digitalization (harnessing digital innovation, business models and infrastructure).
- Cross-border research and development initiatives (development centers: increase of cooperation between institutions).
- Smart management of development funds (centralization of development investment decisions and active attraction of strategic investors).
- Launching a healthy core business (creating conditions for continuous operating).

We certainly can say that integration of smart devices, digitalization and robotization of working processes in Slovenian companies is increasing gradually. The employees will face huge changes in companies, from owners, directors, top management teams and all the way to employees in working processes. However, we should look at those changes as new opportunities from which we want to get as much added value as possible.

4.6 Public tenders

An important part of implementing new technologies into certain companies is correlated with investments. Many companies are prepared to implement new technology, but when it comes to the financial stage, they cannot afford those investments. The reasons are that they do not want to take that much risk, or they just cannot afford it based on their profit. In the 21st century, the technologies we are using are getting more affordable every year. However, newer technologies which can push and diversify a company from the competition are usually remaining very expensive. To make those investments more affordable not only for big players with higher revenues but also for smaller companies, there are public tenders provided from the countryside and the European Union.

It is in the interest of both (the country and the company) to improve and increase the level of new technologies used. So not only companies become more competitive but also the country might get positioned higher on the list among other countries. The latest figures from the International Federation of Robotics show that Slovenian industrial companies use 144 robots per 10 000 employees. That puts Slovenia in the 16th place globally and ahead of advanced economies like Switzerland, France and the UK. For comparison, the European Union average is 106 robots per 10 000 workplaces. The automotive sector in Slovenia scores even better (Invest Slovenia, 2019).

A short research on the adoption of Industry 4.0 was carried out in 2019 by the German-Slovenian Chamber of Industry and Commerce (AHK) where for 87 percent of all surveyed companies' digitalization was a top priority. Fifteen percent of all surveyed companies have still not started with the digitalization of processes. According to AHK, the weakest link for preventing even faster digital transformation is the people or rather their limited ability to constantly adapt to rapidly changing competences (Invest Slovenia, 2019).

Digitalization is not reserved only for big companies such as Revoz or Krka, which are throughout equipped with robots, but it is also suitable for a smaller company like Polycom which is a mid-sized, family-owned company and is presented as one of the smartest factories in Slovenia.

Interesting public tender Incentives for digital transformation are prescribed for micro, small and medium sized business. They are provided by Public Funds with cooperation by Ministry of Economic Development and Technology and by European Regional Development Funds.

SID (Slovenska izvozna in razvojna banka) and SPS (Slovenski podjetniški sklad) signed a financial agreement in 2018. By 2023, a total of EUR 42 million in financial incentives will be available through SPS in the form of microloans, which SPS must provide to sole proprietors, micro and small enterprises, and start-ups. The tender will finance the companies that are introducing (SPS, 2019):

1. Digital transformation of key production and business processes:

a. improving the customer experience,
b. efficient collection and processing of data visualization,
c. development of processes and digital solutions to support business and production,
d. digital staffing and jobs development,
e. cybersecurity,
f. Industry 4.0 in general.

2. Technical equipment:

a. software or hardware that enables digital business.

(SPS, 2019)

5 RESEARCH METHODOLOGY

Our research model should provide us with the answers we need to achieve the goal of helping the three Slovenian companies with the new Industrial Revolution 4.0. To successfully reach the goal of the master thesis, and to create a useful survey, we first held a pilot interview. This interview helped us later make some minor changes and improve the questions, so that we could get better results in interviewing the three companies.

In this empirical part of the thesis, we focused on three main areas: the company's current status of Industry 4.0 and technologies they use, implementation problems with overall impressions of already implemented technologies, and their future intents. We decided on a qualitative method of research, namely through a semi-structured in-depth interview because it allows for an open conversation around the topics. When selecting the interviewees, we tried to get people in positions of technology, manufacturing and HR. Finally, we were able to conduct the interviews with almost all wanted positions. The list of questions based on research questions and theoretical starting points is attached to the master's thesis.[1]

5.1 Pilot interview

The interview was conducted with an employee of the venture lab department in Company C portfolio for Industry 4.0. From the four branches, Company C is divided into (Mobility Components and Systems, Power Engineering, Engineering Technology and Systems, Digital); the venture is working in the Digital one. They are working in a B2B environment.

For the employee industry 4.0 means: "correctly extracting, sorting and using the data". From his point of view, Company C is doing well in the field of digitalization, but even better in the field of automatization. They are already using the following technologies: 3D-printing, additive manufacturing, VR, Big Data, Cloud Computing, Cybernetic systems, IoT, Robotics, Smart-factory, CPM, CRM, ERP and Usage of smartphones in business processes. In the next couple of years they want to achieve process connectivity /integration. The technologies they use are based on the one of the four branches they work in. But more or less, all sectors use a lot of robotics and automatization. All those technology implementations ware partially financially supported by the EU. The employee fully- agreed that all those technologies will/would: increase efficiency, decrease costs (also with their business partners), simplify the business, and make the company look more professional / successful / stable. When the interviewed person was asked about how he sees the implementation obstacles we got the following results. They do trust industry 4.0 and are not afraid to depend on it. Overall, the employees of the company are in favor of industry 4.0. However, when it comes to data security, they still do have certain fears, even though they have their own data/cybersecurity. Overall, they are more than happy with the current Ind. 4.0 technologies and are ready to implement more of the same and new technologies.

[1] To preserve interviewees' anonymity, the transcript of interviews is available upon request from the authors.

The industrial change still presents a huge challenge in the company even though they already implemented quite a lot of technologies and already have those integrated departments inside the company. Because it is not just the implementation that is challenging but also the structural and organizational change which is difficult. Their biggest challenge is still non-acceptance, and it comes to the so-called "promotors" to bring the new technologies and changes closer to employees, so that they can accept them. In addition, data-security presents another challenge.

Digitalization helped them in all fields of the business, but the highest impact was on productivity, since one can have the same or better outcome with fewer resources. The main technology that makes them competitive in their environment is MV (machine vision).

They could still achieve better results if there was a higher level of integration of processes. The most integrated is the production process, whereas the storing process still has room to improve (Automated storage).

This results in people working in the production to have the most knowledge about Industry 4.0. People are extra trained for the emerging technologies so that there will not be any redundant staff left since it is always cheaper to educate a current employee than to hire a new one.

They measure the improvement / changes in Industry 4.0 by tracking how many technologies and startups inside Company C were implemented.

5.2 Company A

In Company A, we had the opportunity to talk with the (DEN Automation) Technology Manager, Head of regional HR and Director of Production. The **first interview** was conducted with (DEN Automation) Technology Manager from Company A.

He understands the concept of Industry 4.0 as the German government strategy, to make the next step towards the new industrial age, with the connectivity of the smart devices/computers/robots that were presented in the previous Industrial Revolution, and also new ones. Company A is a good example of a company that is partially already digitalized, in one segment more than the others. They are on a good path to fully implement Industry 4.0 in their everyday routine, but the journey will take a decade. They use most of the standard technologies like 3D printing, Cloud computing, IoT, RFID, Robots and similar. There are other technologies that they have not implemented so far, but they intend to in the next three to five years.

The employee fully agreed that all those technologies will/would: increase efficiency, decrease costs and make the company more professional / successful / stable. But he partially agreed that the technologies would simplify the whole business, since the new Industrial

Revolution also brings along new challenges to face. The whole company must learn and acquire new skills before the whole process works perfectly, and the business is simplified.

When the interviewed person was asked about how he sees the implementation obstacles, we got the following results. They do trust industry 4.0 and are not afraid to depend on it. Overall, the employees of the company are in favor of industry 4.0. However, when it comes to data security, they still do have a certain level of precaution, that is why they have their own data/cybersecurity. They also had some troubles gaining the fundamental new knowledge needed to cope with the new technologies and adopt the cultural changes inside the company. Overall, they are more than happy with the current I4.0 technologies and are ready to implement more of the same and new technologies.

The technologies helped them in all fields of the business, but the highest impact was on productivity/ efficiency. They can produce more products faster and provide a better working environment for the employees. By gathering and storing all the data from production, they improved in the fields of process stability, after-sales and complaints support as well as designing of new products. However, most importantly, the company is gaining new knowledge and builds competences to keep the market leader position on district and residential energy heating segment.

The **second interview** in Company A was held with the head of regional HR and Director of Operations. They both had their own opinions and views on Industry 4.0 in the company. When they were asked about the term industry 4.0, the production manager described it as a set of innovations and introduction of new technologies into production, with which we want to increase productivity. The focus should be put on digitalization and robotization, with more transparent monitoring of events.

The head of regional HR had her own definition of the term Industry 4.0 with more focus on the employees. In her opinion, the term means the modernization and automatization in a company, which affects the employees in a way that they have less routine work, which also leads to fewer health problems. On the other hand, the work is more demanding, because people need certain competences. It helps a lot if they are interested in the topic and able to learn fast. They continuously develop and train workers according to the new needs the technologies bring so that they can keep the existing workforce. Besides that, workers have the opportunity to be part of a department rotation program, which means that they can switch their working positions based on demand and always have enough work to do.

They both see the company as well-digitalized and well-positioned among the companies that have implemented Industry 4.0 technologies, being among the best ones in Slovenia, but still trying to improve on the global level.

The company uses most of the technologies usually used in Industry 4.0, except blockchain technologies. The driver for implementation for all of those was the increase in productivity. With the implementation, they reduce operating costs, transaction costs and present the company as professional and modern. They are aware that technologies are changing the environment in which they work, and if they do not adjust to those trends, they will probably drop out of the market.

Both interviewees agreed that they trust Industry 4.0 but do agree that there are some risks when depending only on technology. For example, if the network crashes because of unstable or no Internet, the whole production is stopped. In addition, data security presents an important risk that has to be taken into consideration, which is why Company A has a specialized IT team that takes care of security. Overall, employees do support the implementation of new technologies and are generally satisfied with them. They are willing to implement more of the same and new technologies.

When we asked about the implementation barriers, both agreed that every implementation has its challenges. Especially the company culture is at stake when people are afraid of upcoming technologies. However, Company A in general, has employees that are willing to adapt to the rapidly changing environment with new technologies and are not afraid of constant change. When the changes are made systematical and tactical, there is no need to worry.

The head of HR knows that soon they will need more employees with digital competences, since the complete manufacturing process is getting digitalized and robotized. The production manager agreed and said that they always try to get people with the technical educational background (engineering, IT). But most important new employees need to be open to new knowledge and willing to learn.

5.3 Company B

At Company B, we had the opportunity to talk with the **Head of HR and Production manager**.

The **first interview** was conducted with the head of the HR department. For him, the term Industry 4.0 means automation of production and logistic processes, everything that contributes to reducing the manufacturing time and increases quality.

He sees the company in the beginning phase of the transformation towards Industry 4.0, with partially digitalized processes. They are trying to outsource some of the processes, which is not always cost-efficient. Besides, with outsourcing, you lose some knowledge inside the company, and you become dependent on the outsourcing partner. The HR department is trying to do its best to make processes automatized and digitalized in their segment. They are not using any new technologies in the process of hiring new employees, but some tasks are rather assigned to leaders of other departments where the new employee will work. However, he thinks that soon (in less than two years) most of the hiring process will be automatized. Still, the human touch will be needed in a way to attract new workers and help them choose the right path.

He told us about his view on working from home during Corona pandemic. The company had to adjust to working from home, and employees had to be flexible and digitalized to maintain the normal workflow. However, home-office work results in fake productivity, since it is hard to organize your time at home. It was a test that showed how many people can normally work from home.

He believes that there will be an excess of stuff since many processes will be automatized and digitalized. The ones who will not be able to adapt to the rapid changes and be willing to learn will not be able to maintain their work positions. While hiring, they do not specifically look for industry 4.0 competences, but rather to employ someone who is right for that position, at the right time.

The **second interview** was conducted with the production manager. For her, the term Industry 4.0 presents digitalization. She sees the company as partially digitalized, by using most of the common technologies present in Industry 4.0. They already use 3D printing, Big Data analysis, robotics, automatized production, CPM, ERP and smartphones in their company. All other technologies like AR/VR, Cloud computing, blockchain, CRM and a digitalized warehouse, they intend to implement in the next 3-5 years. The manager fully agreed that the implementation of those technologies increased their efficiency, reduced costs, simplified their business and made them look more professional.

The huge investments in technology and digitalization pay off after some time, with increased productivity, better tracking of products, lower costs, less low-quality products. Most technologies and improvements are present in the development and production sector. Where data is gathered, it is used for learning, planning and optimizing processes. It is also important that they correctly analyze the consumer data since patients are their main customers.

She is aware of the fact that the technology is shaping the markets in which they are present, meaning that if they do not adjust to the rapidly changing technologies and digitalization, they will no longer be competitive. They track their own Industry 4.0 progress with automation and digitalization implementation indicators.

She trusts the technologies of Industry 4.0 and is not afraid to depend on them. The employees, more or less support I 4.0 and overall experience with their implementations are great. However, they have some concerns about data security. That is why they have a couple of services and departments working on that.

They had some minor challenges implementing the Industry 4.0 changes, but not any different from all other changes that were made so far. The problem might be with lower educated employees and older ones, since they will not be able to adapt to the rapid changes happening right now. Nevertheless, HR departments are doing their best to guarantee them the education needed.

The manager also gave us an insight into the latest Corona adjustments they had. In the coronavirus situation, their production worked normally as it is largely automated. They had good practices of working from home and all the necessary applications, so most people in home-office ensured the smooth production.

5.4 Company C

At Company C we had the opportunity to talk with the **Director of Company C Ventures and Executive director of production and with the head of HR.**

The first interview was conducted with the Director of Company C Ventures, which is a corporate VC fund investing in early-stage start-ups in the field of Industry 4.0. She is also a member of the core team in the Company C Digital segment, which is developing solutions for smart factories.

She considers Industry 4.0 as new technologies, which if implemented correctly result in increased productivity. Industry 4.0 might also represent new opportunities for implementing new business models. Company C can be seen as a well-digitalized company, but still does not operate as a full Smart Factory, nor is it seen as a digital champion. Generally, in Europe, there are only a few companies that are considered digital champions. They already have most of the technologies of Industry 4.0, except blockchain technologies and RFID. Most important from all technologies for them are AI and collaborative robots, to stay competitive. They usually receive support from the countryside when implementing new technologies in a form of subsidies.

The Director agreed that those implemented technologies improved their efficiency, decreased the operating costs, and simplified their business. She partially agreed that the implementation helped decrease the transactional costs with their business partners, and that the implementation helped them to look more professional. They were able to decrease organizational bottlenecks, decrease assembly times in the production and they made knowledge transfer better and faster. With the help of technology, they are also capable of solving problems remotely from distant locations.

Technology has an impact on the markets they operate in. Since they are a B2B business, their customers are implementing new technologies in their companies as well, and therefore expect Company C to do the same. If you are not always following the modern trends and technologies, you eventually lose the race and fall out of the market. They are tracking their progress in Industry 4.0 with indicators such as efficiency, inventory reduction, decrease in organizational bottlenecks.

They fully trust Industry 4.0 technologies and are not afraid to be dependent on them. Employees support those new implementations, and do not worry about data security. They have that area well covered with internal servers and cloud solutions. The Director said it well:” If you want to implement Industry 4.0 in your company, you have to take care of the data security”. They make use of their captured data mostly when it comes to business analysis, and for building new algorithms in the productions with the help of artificial intelligence (AI).

Overall, they have a positive experience with the implementation of new technologies, but since many technologies were so-called pilot projects, they also had some negative encounters while implementing. Mostly because many new technologies do not have case studies, from which one could extract useful knowledge. Therefore, they are doing their best to prepare the employees for new working positions that require additional technical knowledge.

In the **second** interview, we had a conversation with the head talent acquisition and employment coordination of HR department. He interpreted the term Industry 4.0 as the industry of the future, with a large number of IT technologies, robotization, where the shift will not cause a decrease in labor, but rather free the workers from physical activities. Lower qualified workers with basic education will have to adapt to new technologies, with willingness to learn new things. He perceives the company’s level of Industry 4.0 the same as the Director of Ventures, where the HR department should be more digitalized according to him. When it comes to hiring the right personnel, the Venture department hires on his own, whereas at the company itself heads of departments usually determine which skill sets are needed for a position. The new age of technology also affected the way of hiring people. These days most employees come through channels like LinkedIn, where digital competencies are listed, which are needed for a specific position that has to do with new technologies. They do not use AI and other software to filter candidates in the process of hiring, but rather do personal interviews. The department is willing to implement technologies that might help them recruit the right people faster. Currently, most wanted and needed positions are in the area of IT and robotics, and mechanical and electrical engineering in the area of the automotive industry. Because some of the wanted profiles are hard to get, they co-operate with learning institutions (faculties) and provide scholarships. New employees, even though they come with the right competencies and are fast learners, still sometimes have trouble adjusting to the fast-changing environment of Industry 4.0.

6 RESULTS AND FINDINGS

6.1 Findings

In all the companies, it was noticeable that the digital transformation is happening mostly in the research and development segment as well as in the production, which still leaves a lot of potential in other segments such as warehousing, logistics, services, purchasing and sales. Many of our respondents see cost reduction and competitiveness as the main advantages of Industry 4.0.

With the analysis of interviews, we observe that the differences in opinion about Industry 4.0 can be seen within the company. If we firstly focus on **COMPANY A,** we can immediately notice the difference in the explanation of what Industry 4.0 is. The main differences are not only based on the position of the interviewed person but also among the same positioned ones.

Asking our first technical positioned person (**Director of Operations**) to explain what Industry 4.0 is, resulted in a very technical explanation: "*Industry 4.0 is a set of innovations and introduction of new technologies into production with which we want to increase productivity. The emphasis is on digitalization and robotization with transparent monitoring of events*". The second explanation from a technical personal (**Technology Manager**) was: "*Industry 4.0 is German government strategy, to make next step towards new industrial age, with the connectivity of the smart devices, computers and robots*." We can see that both technical personas have their own explanation, but it goes towards the same direction.

By asking the **Human Resource employee** to explain what Industry 4.0 means, we received a slightly different answer: "*Industry 4.0 means modernization and automatization in a way that employees have less routine work, which also leads to fewer health problems.*" Understandable that she focused more on employees. All three have the same opinion that **COMPANY A** is well digitalized and well-positioned among the companies that have implemented Industry 4.0 technologies in their everyday routine. Being among the best ones in Slovenia does not mean that you should stop implementing new technologies if you want to improve on the global level and be more competitive on the market. They also agree that they use most of the technologies which are most common for Industry 4.0 except blockchain.

When we asked what drives them for implementing new technologies, all three had the same opinion – increase in productivity, reduce operating cost and to present the company as more professional. They are aware that the implementation of new technologies is very important, due to the changes on the market. Otherwise, if one does not follow those trends, one could drop out of the market because of fierce competitiveness.

Overall, all three trust Industry 4.0 and are not afraid to depend on it, even employees of the company are in favor of Industry 4.0. As far as obstacles are concerned, they say that each implementation of new technology has its own challenges. The technology Manager and Director of Operations have a certain level of precaution and see problems only with data-security. To avoid such problems with data, they are using their own data-secured server. Human Resource employee emphasized that they are aware that soon they will need more employees with digital competences because of the increase in digitalization and robotization. But they are not looking only for an expert from each field, but more for people with some technical background and openness for new knowledge and willingness to learn.

In **COMPANY B,** which is present in the Pharmaceutical industry, we did two interviews (with the Human Resource employee and Production Manager). The same as before different positioned employees had different opinions on what Industry 4.0 means. The **Human Resource employee** explained Industry 4.0 as: "*Industry 4.0 means automation of production and logistic processes*", whereas the **Production Manager** explained it as: "*Industry 4.0 presents digitalization".*

They both see **COMPANY B** as partially digitalized, by using most of the common technologies present in industry 4.0. Usually, they outsource some of the processes, which is not always cost-efficient and by assigning tasks out of the company, you lose some know-how inside the company and become depended on the outsourcing partner. Both agreed that investment in technologies of Industry 4.0 pays off after some time with increased productivity, better tracking of products, lower costs, less low-quality products. For now, most of new technologies and improvements are present in the development and production sector said the Product Manager. On the other hand, the Human Resource department is trying to do its best to make processes automatized and digitalized, but for now they are not using any new technologies in the process of hiring new employees.

They both agree that technology is shaping the markets in which they are present, meaning that if they are not capable of adjusting to rapid changes in new technologies, they will not be competitive anymore. This is also the reason that they will fully automatize their hiring process in less than two years and implement all new technologies they are not using now (AR/VR, Cloud computing, blockchain, CRM and a digital warehouse) in the next three to five years. They did not encounter any special obstacles while implementing new technologies of Industry 4.0. But according to the Production Manager, the problem is with lower educated employees and older ones, since they will not be able to adapt to the rapid changes happening right now. Nevertheless, the Human Resource department believes that there will be an excess of stuff since many processes will be automatized and digitalized. Human Resource employee emphasized that the ones who will not be able to adapt to the rapid changes and be willing to learn will not be able to maintain their working position.

COMPANY C is a part of the automotive industry and it is globally known. At that company, we did two interviews (the Human Resources employee and Executive director of Production). With different explanations, the **Human Resource employee** explained Industry 4.0 as: "*Industry 4.0 is the industry of the future, with a huge amount of IT technologies and robotization. Where the shift will not cause a decrease of labor, but rather free the workers from physical activities.*" Explanation of **Executive director of Production** was a bit more specific and focused on production: "*Industry 4.0 are new technologies that if implemented correctly lead to increased productivity. Industry 4.0 might also represent new opportunities for implementing new business models*." The Human Resource employee focused more on his area of work – on employees, while the Production director focused more on new opportunities and business models.

Both agree that **COMPANY C** production is well-digitalized but still does not operate as a full Smart Factory. The Human Resource employee also emphasized that the HR department could be more digitalized. Production is already using most of the Industry 4.0 technologies, except blockchain and RFID. They agree that to stay competitive, you should start implementing Artificial Intelligence and collaborative robots into production and do some digitalization changes in other departments.

Implementation of new technologies improved their efficiency, decreased the operating costs and simplified their business. It also helped them to look more professional and to decrease organization bottlenecks.

They both agree that if you are not always following the modern trends and technologies, you eventually lose the race and fall out of the market because you are not competitive anymore. Employees fully support new technologies, and they are willing to learn, otherwise they know that they will be relocated to another position. Currently, the most wanted position is in the area of IT and robotics. Overall, they have a positive experience with the implementation of new technologies.

6.2 Company A/B/C (current situation/implementation problems/future intents)

Based on all the interviews we have conducted, company C is currently the most digitalized and adapted Industry 4.0 best, followed by companies A and B. Probably because they have a whole (venture) department dedicated to new technologies and startups. All the companies already experienced increased efficiency / cost reductions because of the newly implemented technologies. However, they all at some point, had difficulties while implementing them. Most common reasons for application barriers were new knowledge that comes with the technologies and the willingness of people to learn. We found out that they do plan to send their employees to workshops and other learning courses so they will not have to fire them but just create new working positions for them. Only older people who are not aware and capable of adjusting to the digital trends may be problematic.

Overall, all companies intend to invest more in Industry 4.0 in the future, since they are aware that if they do not, they will not be competitive anymore.

Table 5: Overview of the current situation in the companies

	Company A	**Company B**	**Company C**
Industry 4.0 phase	Beginner phase /Partially digitalized	Partially digitalized/ Well digitalized	Well digitalized
Technologies used	3D printing, Big Data analysis, robotics, automatized production, CPM, ERP and smartphones	All except blockchain	All except blockchain
Technology impacting their markets	Yes	Yes	Yes
Implementation challenges	Lower educated employees and older ones	Knowledge/ Company cultural changes	Knowledge

Source: Own work

Table 5 shows the comparison among three interviewed companies. We can see that all three companies already started implementing technologies of Industry 4.0, but they are in different phases of implementation. The differences are noticeable because the companies are present in different markets, and technology affects each industry differently. The most digitalized is Company C which is operating in the automotive industry, and the least digitalized is Company A which is in the heating industry. This confirms previous findings that the automotive industry is the most advanced and is committed to using the latest technologies on the market. Using the new technology helps them to stay competitive on the market and to expand their business. On the other hand, we have Company A, which is not that dependent on using the latest technologies but more on the development of new products. All three companies agreed that technology somehow impacts their market. All companies had some challenges with the implementation. The most common challenge is not having enough knowledge to operate all new technologies.

7 DISCUSSION AND SUGGESTIONS

The goal of the master thesis was to analyze three Slovene companies and see how they are facing the industrial changes of Industry 4.0. In this chapter, we will fulfil the purpose of the thesis by providing general suggestions for the companies to help them cope with new technologies and digitalization

Based on our findings, all three companies are already in the Industry 4.0 transformation phase and have a lot of technologies already implemented. However, none of them fully use blockchain technologies, and all of them had some difficulties implementing the changes Industry 4.0 requires. In this chapter, we will discuss why they should use blockchain technologies and review some general solutions for easier Industry 4.0 implementation and adaptation.

Based on four stages of Industry 4.0 presented by a PWC in Figure 24, we could say that none of the companies is yet a digital champion. But they are all on a good path of becoming one, since they already invested a lot in new technologies and knowledge.

Figure 24: Four stages of digitalization

	1 Digital novice	2 Vertical integrator	3 Horizontal collaborator	4 Digital champion
Business models, product & service portfolio	First digital solutions and isolated applications	Digital product and service portfolio with software, network (machine-to-machine) and data as key differentiator	Integrated customer solutions across supply chain boundaries, collaboration with external partners	Development of new disruptive business models with innovative product and service portfolio, lot size of one, product & component identification
Market & customer access	Online presence is separated from offline channels, product focus instead of customer focus	Multi channel distribution with integrated use of online and offline channels; Data analytics deployed, eg, for personalisation	Individualised customer approach and interaction together with value chain partners	Integrated Customer Journey Management across all digital marketing and sales channels with customer empathy and customer relationship manage-ment
Value chains, processes and systems	Digitized and automated sub processes	Vertical digitization and integration of process and data flows within the company	Horizontal integration of processes and data flows with customers and external partners, intensive data use	Fully digitized, inte-grated partner eco-system with self-optimised, virtualised processes, focus on core competency, decentralised decision making & autonomy
Compliance, legal, risk, security & tax	Traditional structures, digitization not in focus	Digital challenges recognised but not comprehensively addressed	Legal risk consistently addressed with collaboration partners	Optimising the value chain network for legal, compliance, security and tax
Organi-sation & culture	Functional focus in "silos"	Cross functional collaboration but not structured and consistently performed	Collaboration across company boundaries, culture and encouragement of sharing	Collaboration as a key value driver

Source: PWC (2014)

There are high investments needed on the path to become a Digital champion. The economic benefits and competitive advantages those investments will bring need to be critically assessed. There are many ways to become a champion, but companies must choose the right way based on their abilities, operative and administrative processes.

7.1 Organization restructuring

As stated by Porter and Heppelmann (Porter & Heppelmann, 2015), with the complexity of new products that are connected to the Internet and communicate with each other, the organizational structure of companies is also changing. Thus, in a classically structured production company, which is divided into functional units such as development and research, purchasing, production, logistics etc., there is a growing need for logical integration of various functions. The connection between them is essential in developing new product features. According to Porter and Heppelmann (2015), with the advent of smart and Internet-connected products, the classic model of the organization will fail, therefore they are proposing a new organizational structure that allows a rapid flow of information from leading smart equipment developers to data developers for databases and production, which has all the data available in real-time. Following their model, we propose a change in the organizational structure in the direction of strengthening the three main areas of the company that are important for the future adaptations for the 4th Industrial Revolution. Those are: **strengthen information and communication competencies, the introduction of product management in the research and development field** and **program management or customer success management.**

As part of the further development and adaptation to the Industrial Revolution 4.0, upgraded computer systems will automatically upload data from production lines, communicate with products that are being manufactured and with products that are on the market. That is why Industry 4.0 requires new ways of organizing and leading the production. As the number of different sub-systems in the company increases, so does the amount of data that needs to be processed. For current needs, traditional databases are sufficient, and with the expansion of the data set and the demand for real-time data processing, data warehouses will gain new dimensions and the need to upgrade. Providing real-time data will serve more processes in the company, which are not necessarily tied to production, but also to the development of new products and the innovation process in the company. For this purpose, we suggest that the IT departments in the company organizational structure are excluded from the general field and included in the structure as a field entitled "Data Management". The area continues to provide support to the information system, while they need to develop especially in the establishment of a system for capturing data from production, monitoring the status of already manufactured products and devices, as well as capturing data from the market, which can be useful in designing new product strategies.

As stated by Porter and Heppelmann (2015), in the development of new product families, it is necessary to bring together experts in the field of software and data management in the cloud with experts in product development and production. The complexity of the new product development process therefore increases significantly.

Therefore, we also propose a new organizational unit in all the companies, which would be responsible for monitoring market trends, identifying new market segments, managing and optimizing product efficiency as well as product design and support the manufacturing process. The new organizational unit would also establish support for after-sales activities and take care of product upgrades and repairs according to market responses. The task of product management is a comprehensive monitoring of market trends, customer requirements, identification of interesting new segments and development of new products. The product manager participates in the market as a technical sales assistant. Product management connects development and research, sales organization, production, quality and coordinates with product managers of other product groups. With the introduction of product management in the organizational structure of the company, the flow of marketing and sales laws will increase as part of research and development. For successful placement, it will be important for the organization to clearly define the responsibilities between the product manager and the project manager, who take care of the efficient implementation of development projects in terms of time, cost and technical implementation. In order to efficiently and successfully perform the tasks of strategic and operational product management, it is necessary to establish an appropriate level of autonomy and authority for the manager's products.

Similar to what Porter and Heppelmann (2015) have already done in the new organizational structure of the company for the transition to the 4th industrial age, we propose the design of a new program management unit or "Customer Success Management". The main task of the new structure is to manage the users' experience of the product and to manage the data in the cloud, where product data is collected in the market. With the new organization, it is necessary to establish market sensors that measure the values and experiences of users. The new organization establishes a rich database on the use of products, customer preferences and their habits, and on customer satisfaction, which serves the product manager in designing a new product strategy. Program and product management together directly influence and form the company's innovation strategy, which is the key to the company's growth and competitiveness.

7.2 Why the three companies should implement Blockchain

In this chapter, we will present the benefits of implementing blockchain in the following three segments: supply chain & logistics, manufacturing and business in general. Since the analyzed companies do not or just partially use blockchain, we would suggest they implement it for the following reasons:

Supply chain management with blockchain technology is able to track the products and eliminate frauds with more transparent and faster communication of the supply chain. All supply chain processes are enabled with production, processing, warehouse management, distribution and retailer's links. Transparency and accountability are therefore increased, resulting in enhanced efficiency and reliability of processes. Even like customer satisfaction, dependence on documents for authentication, difficulties of tracking records and real-time tracking can be solved with blockchain technologies. (Bodkhe et al., 2020)

Manufacturing with blockchain technology enables new operational ways of a Smart Factory with a blockchain-based collaborative manufacturing model and demand management. If able to apply blockchain-enabled Cyber-Physical System architecture for Industry 4.0 manufacturing systems, one can generally increase performance. Normal manufacturing processes basically use the centralized networks which have problems such as security, flexibility, availability, and efficiency, which can be solved with blockchain technologies (Bodkhe et al., 2020).

Business with blockchain technology generally increases its security, solving challenges like personal information leakages and single point of failure with centralized databases. The blockchain mechanism uses decentralized systems for the distributed handling of data. A clustered hierarchy is used for data storage and backup that eliminates the probability of losing the data. In addition, it replaces all physical document-based transactions, with the integration of electronic lading bills and transparent liquidity. Businesses are less likely to encounter data losses and security problems with blockchain technologies (Bodkhe et al., 2020).

7.3 General industry 4.0 implementation suggestions

The suggestions are based on a study done by Deloitte and will be presented in four different segments: vertical networking, horizontal integration, through-engineering and exponential technologies.

7.3.1 Vertical networking

For the vertical to work, three main areas need to be covered to achieve new operational efficiency. IT integration is the first of those components. Usually, many IT structures in companies are fragmented, resulting in poor networking. To prepare for the new industrial change companies should develop new combined solutions based on components from suppliers, control systems, business applications and customer-facing applications. Analytics and data management also needs to adapt, since Industry 4.0 generates an enormous amount of data. Companies should have special data analysts hired or help existing ones develop new skills needed for efficient data management. Later they should be prepared to adjust their business models based on the analysis. Claud –based applications already are crucial in many companies to operate with the big data generated. This makes it simpler to gather, monitor, and analyze data between departments and even factories (Deloitte, 2015).

7.3.2 Horizontal integration

For the integration to work, the business model needs to be optimized. To achieve optimization, companies need to develop new skillsets at employee levels as well as within the organization as a whole. Successful companies will develop new segments on the edge of their current business, which will later become its center.

New business models will likely be based on individual customer needs, which will result in new demands in the supply chain. Companies need to align different departments more closely from R&D, procurement and sales, production with the supply chain. Successful companies will use better communications to integrate suppliers' and customers' needs into all value-creation activities.

With all that high-level data sharing happening in Industry 4.0 IT, security management needs to be well developed. Companies need a tailored risk management system and a security strategy to improve operational security and to be protected from attacks across the value chain. Here the manufacturing sector generally lags behind the financial one. New products, data and intellectual property need to be protected against unauthorized use/ abuse. Therefore, companies should also develop new IP (intellectual property) management.

7.3.3 Through-engineering

Industry 4.0 will enable integrated and cross-disciplinary engineering, with no limitations in the traditional area of product innovation. Companies, therefore, need to use other potentials besides traditional product offering. New potential lies in the areas of processes, networks, and customer-facing functions like new services and distribution channels. Efficient management of innovation takes in the entire company and covers strategy, organization, project portfolio management and product development. Companies should use Industry 4.0 solutions in the project portfolio management since it enables them to easily track ROI (return on investment) in innovations and also helps them identify risk by comparing global comparative data. Companies should also try and use AI (artificial intelligence) in the fields of life cycle management, to understand and meet their customers' needs better (Deloitte, 2015).

Table 6: Efficient innovation management with Industry 4.0

Training	For professionalism and creativity. Including will and ability for teamwork organization. Training in the form of formal education, seminars, manuals, practice.
Research prognostic starting points	Information about the values, culture, ethics, norms and interests of the company
Company vision and policy	Long-term, economically successful and socially responsible business. An idea of an innovative company and the market we want to achieve with our innovations.
Mission	Great achievement of systemic quality of the entire business, not just products.
Goal	Meeting the needs of employees and long-term performance of the company
Vision	Ability to sustainably develop the company and increase its market value

Source: Čič & Žižek (2018)

7.3.4 Exponential technologies

Companies usually try to make use of corporate ventures when it comes to investing in new technology trends at an early stage. Companies should invest in start-ups so they are involved in the developing process as well as to secure their long-term competitiveness. Companies need to become learning organizations if they want to make full use of exponential technologies and Industry 4.0 in general. The adjustment to new exponential technologies needs to be gradual but steady, since with change that is too rapid comes counterproductivity. New ideas and processes are most successful if implemented as a niche where learning goes on and then later migrate into the center of the company.

7.4 First steps on the path of digitalization

Regardless of which path the company chooses, there are always three basic pragmatic steps to achieve the wanted Industry 4.0 level. All things need to have an ID, need to be measurable and be connected & analyzed. All products and materials should have a bar code or RFID code, to digitize and connect products in the value with clear identification. This allows product data to be collected and described which fosters efficient inventory as well as supply chain management. Measures need to be done across the entire value chain to track the current state of products and material. The availability of measured data allows companies to improve processing times, increase quality and decrease costs. Products need to be closely connected and identified based on the production materials and processes. An IT structure to analyze real time data is also necessary. With all the steps mentioned above, it is easier to implement Industry 4.0 (PWC, 2014).

7.5 Use of funds and subsidies

The last suggestion from our side would be the use of public fund and subsidies related to industry 4.0. Some companies partially already helped finance themselves with existing funds, where others have not. As mentioned in chapter four, money for enabling technologies and innovation can be received from the countryside as well as from EU funds. The companies should apply for the EU Horizon program and follow the actions from ESIF (European Structural and Investment Funds), since they are willing to provide huge amounts of money for research and innovation in EU. On the country level, companies should take part in the project provided by GZS (Gospodarska Zbornica Slovenije) named Slovenia 5.0. In addition, SID (Slovenska izvozna in razvojna banka) and SPS (Slovenski podjetniški sklad) are financially willing to support Slovene companies that are undergoing a digital transformation.

Besides funds, companies can also ask for subsidies that reduce the environmental impact. As mentioned in chapter one, all these new technologies will reduce the negative impact industry has on the environment. In Slovenia, we have the so-called “EKO skladi”, which is basically an Eco Fund, which was established as a legal public entity under the 1993 Environmental Protection Act. Its main purpose is to promote development in the field of environmental protection. In Slovenia, it is the only professional organization to provide financial support for environmental projects. The financial aid is supported primarily by soft loans from revolving funds and by grants since 2008. The key advantages of the Eco Fund in the environmental funding market relative to commercial banks are that it offers soft loans at lower interest rates than the prevailing commercial market rates and is able to lend for much longer periods than commercial banks. Latest analyses of the effective interest rates of loans from the Eco Fund, on the one hand, and those of commercial banks, on the other, have shown that it is possible to save a total of 15% of the cost of an investment when opting for a loan from the Eco Fund.

Since Industry 4.0 technologies improve energy efficiency and reduce pollution & waste, companies that implement those technologies could benefit from such subsidies or similar ones (Ekosklad, 2020).

8 IMPLICATIONS BEYOND THE STUDIED CASES

The practical implications of this study derive from both the theoretical and empirical elements. Various consulting agencies' reports such as PwC's and Deloitte have addressed and analyzed the Industry 4.0 within companies. Overall practical implications of this thesis can be relevant for companies that are in any stage of Industry 4.0 even if they have not started yet.

This study is limited in the size of the sample, due to the methods of research and the broad topic. The results of the study are therefore not generalizable. Rather, they only portray the situation in the three mentioned companies. In order to get the whole picture of Industry 4.0 in Slovenia, one should use a survey approach instead of an interview. And still the results might not show the current situation since Industry 4.0 and its technologies can be seen as a company competitive secret. Qualitative results give us answers that might differ according to the interpretation. Quantifiable results, on the other hand, are generally easier to interpret, but sometimes harder to get. In our case, the companies would reveal too much if they told us everything about their Industry 4.0 advantages. Furthermore, the individual case studies were not examined over longer time periods but are reflecting past experience from current viewpoints of the interviewees, briefly touching upon future plans.

We have used multiple sources to obtain the data to ensure validity, but most analysis rests on transcripts of interviews. We gained some experience through the pilot interview before conducting other interviews. In our analysis we also included some theory that precedes the empirical part of the thesis, meaning that we have thoroughly understood the subject and studied and analyzed several previous studies. This contributed positively to the quality of the analysis of transcripts.

With the help of our master's thesis, companies should be able to understand the basics of Industry 4.0 and smart factories. Furthermore, we listed all the benefits the implementations bring and provided some solutions to overcoming the barriers on the way to achieve them. This master thesis should be used as a guide for companies which are in the beginning phase of implementation Industry 4.0 technologies and to those who want to gain insights into Industry 4.0 on the Slovenian market. We compared our results with the theoretical part, which is mostly based on research from all around the world.

These master's thesis findings correlate with previous study cases since results show the same problems and benefits of usage of Industry 4.0. Future research should be done in the area of Industry 5.0 since it is inevitable. The concept of evaluating the data could be done by qualitative data collection methods - interviews or by a survey.

CONCLUSION

Today we face many diverse and interesting challenges, especially in the field of technological revolutions that will forever transform humanity. The fourth Industrial Revolution will fundamentally change our outlook on work and everyday life.

Industry 4.0 brings trends and changes in several areas and several industry segments. Compared to other Industrial Revolutions in the past, the fourth revolution is developing very fast. Being among the market leaders and maintaining competitiveness is very difficult today. Industry 4.0 and its technologies are currently the core of competitiveness. All the guidelines suggest that in the future companies will have to implement the Industry 4.0 concept into their operations and ensure a sufficient level of digitalization in their companies, as otherwise, they will lose market competitiveness or, at worst, even risk their very existence.

Digital competences are crucial in understanding and implementing new technologies, yet a large percentage of people still do not achieve a sufficient level of digital literacy. In production, the problem arises in older workers, who, due to the lack of appropriate competencies, find it much more difficult to adapt to change, and companies are therefore forced to provide them with an appropriate level of these competencies in various ways.

In this thesis, we attempted to study Industry 4.0 in three big Slovene companies which are present in different industries. Our research covered the technologies of the new Industrial Revolution as well as their impact on the economy and employment. A large part of our discussion was dedicated to implementation guidelines and suggestions on implementation.

From our small but diverse number of interviews, we have learned much about the current state of Industry 4.0 in the companies, which partially reflects the situation in Slovenia. Among the problems hindering the integration of Industry 4.0 in enterprises is primarily data security. This was also a common finding among the interviews done. There are also problems with job restructuring, as these new jobs will require much more knowledge and skills. All in all, we have found out that the current situation in the three Slovene companies is more or less similar to the situations all over the world.

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APPENDICES

Appendix 1: Extract in Slovenian language

Magistrska naloga z naslovom "*Analiza prispevka tehnologij industrije 4.0 v izbranih Slovenskih podjetjih*" podrobno opisuje tehnologije in ovire, ki jih prinaša 4. industrijska revolucija. Doprinos 4. industrijske revolucije pa prinaša popolnoma spremenjen pogled na vsakodnevno delo in življenje.

Industrija 4.0 prinaša nove trende in ovire na mnogih področjih znotraj različnih industrij. V primerjavi s prejšnjimi industrijskimi revolucijami se zadnja, četrta revolucija, razvija z visoko hitrostjo, kar pa predstavlja velik zalogaj pri konkurenčnosti in ohranjanju le te med vodilnimi podjetji. Današnje merilo konkurenčnosti predstavljajo tehnologije Industrije 4.0, ki pa prav tako kot že zgoraj omenjeno, prinašajo veliko ovir na vsakodnevnih poteh.

Vsi novodobni trendi in smernice napovedujejo, da bodo podjetja za ohranitev konkurenčnosti ali celo njihovega obstoja, morala na različnih področjih pričeti z implementacijo koncepta Industrije 4.0. Kljub temu pa je pomembno, da bo implementacija dosegla zadosti visok nivo digitalizacije.

Digitalne kompetence so ključnega pomena pri razumevanju in implementiranju novih tehnologij, kljub temu pa imamo še vedno velik delež ljudi, ki ne dosegajo zadostnega nivoja digitalne pismenosti. V proizvodnji, starejši delavci predstavljajo največji problem, saj se zaradi pomanjkanja znanja in razvoja soočajo s težavo pri rokovanju z novimi tehnologijami. Podjetja so tako rekoč prisiljena, da na različne načine izobrazijo kader za ustrezno opravljanje delovnega mesta.

S tem magistrskim delom sva se želela približati Industriji 4.0 znotraj treh slovenskih podjetjih, ki delujejo na različnih področjih. Raziskava tako zajema popis novih tehnologij zadnje industrijske revolucije in posledice, ki jih povzroča na ekonomskem in zaposlitvenem področju. Večinski del diskusije je posvečen predlogom in smernicam pri implementaciji koncepta Industrije 4.0.

S pomočjo raznolikih intervjujev sva dobila dober vpogled v trenutno stanje Industrije 4.0 znotraj podjetij, kar pa delno tudi odraža stanje znotraj Slovenije oziroma pri ostalih podjetjih z izjemami.

Med vsemi naštetimi problemi, s katerimi se srečujejo podjetja na lastnih poteh implementacije, predstavlja veliko oviro varstvo podatkov. Ta ovira je bila prav tako prepoznana in označena kot največji problem znotraj opravljenih intervjujev. Problemi pa se pojavijo tudi na področju zaposlovanja, saj nova delovna mesta zahtevajo več znanja in spretnosti. Kljub vsemu pa lahko rečeva, da je trenutna situacija na področju Industrije 4.0 znotraj slovenskih podjetjih več ali manj podobna situaciji po celem svetu.

Appendix 2: Questionnaire for the technical position in Slovenian language

Vprašalnik

Spoštovani, pred vami je vprašalnik, ki sva ga pripravila študenta Miha Povšin in Rok Primožič iz Ekonomske fakultete v Ljubljana. Vprašalnik je namenjen za opravljanje analize na temo industrija 4.0 in bo uporabljena pri pisanju magistrske naloge. S pomočjo vaših odgovorov bomo lažje ovrednotili trenutno stanje vašega podjetja in nato podali predloge za izboljšave. Že vnaprej se vam zahvaljujemo za odgovore.

Ime podjetja: ____

Panoga, v kateri se nahaja podjetje: ____

Velikost podjetja (mikro/makro in pa število zaposlenih na trenutni lokaciji): ____

Glavna dejavnost podjetja: ____

1. Vaša pozicija oziroma naziv v podjetju?

2. Kdo so vaši ključni kupci/poslujete tudi s tujimi kupci?

3. Kaj za vas predstavlja pojem Industrija 4.0?

4. Kako bi ocenili trenutno stopnjo Industrije 4.0 v vašem podjetju glede na zgornjo definicijo? (Govorimo: nismo še prisotni, začetniki, delno digitalizirani, napredno digitalizirani ali šampioni v digitalizaciji)

5. V kolikor ste vsaj začetniki ,prosim če označite katere od spodaj navedenih tehnologij že uporabljate in katere želite implementirati v roku 3-5 let?

	Katere od spodaj navedenih tehnologij že uporabljate?	Katere od spodaj navedenih tehnologij boste v naslednjih 3-5 letih začeli uporabljate?
3D tisk		
Aditivna proizvodnja / modularizacija		
Nadgrajena realnost(AR)/Virtualna realnost(VR)		
Uporaba in analiza velikih podatkov (BigData)		
Delo v oblaku (CloudComputing)		
Blockchain		
Internet stvari (IoT)		

Radio frekvenčna identifikacija (RFID)		
Uporaba robotov		
Avtomatizirana proizvodnja		
Računalniško vodenje procesov (CPM)		
Sistem za management odnosov z odjemalci (CRM)		
Digitalizirano skladišče		
Sistem za planiranje virov podjetja (ERP)		
Uporaba pametnih mobilnih naprav v poslovnih procesih		

6. Zakaj ste pričeli oziroma bi pričeli z implementacijo zgoraj naštetih tehnologij, ki pokrivajo področje Industrije 4.0 (ima to vpliv na podjetje oziroma pridobitev posla, zaradi zahtev kupcev, zaradi konkurence, optimizacije in podobno)?

	Sploh se ne strinjam	Se ne strinjam	Delno se strinjam	Niti niti	Delno se strinjam	Se strinjam	Povsem se strinjam
...menimo, da bi to povečalo našo učinkovitost.							
...pričakujemo, da bo to znižalo stroške našega poslovanja.							
...menimo, da bi to poenostavilo naše poslovanje.							
...verjamemo, da bi to znižalo stroške transakcij z našimi poslovnimi partnerji.							
...želimo, da nas vidijo kot zelo profesionalno podjetje							

7. Ali menite, da tehnologija spreminja trge, na katerih deluje vaše podjetje?

8. V kolikor ste na zgornje vprašanje odgovorili z DA prosim če obrazložite na kakšen način vpliva in kakšne spremembe so vidne? In pa kakšne posledice pušča na vaše podjetje?

9. Ocenite vašo stopnjo strinjanja s spodnjimi trditvami.

	Sploh se ne strinjam	Se ne strinjam	Delno se strinjam	Niti niti	Delno se strinjam	Se strinjam	Povsem se strinjam
Tehnologiji I4 ne zaupamo							
Bojim se odvisnosti od tehnologije I4							
Naši zaposleni ne podpirajo I4							
Bojim se razkrivanja podatkov zaradi I4							

Naše splošne izkušnje s tehnologijo I4 so zelo pozitivne							
Zelo smo zadovoljni z našimi tehnologijami I4							
Če bi morali, bi se ponovno odločili za implementacijo enakih tehnologij I4							
Navdušeni smo nad našo implementacijo tehnologij I4							

10. Sedaj, ko ste že kar nekaj časa deležni Industrije 4.0 ali lahko naštejete katera področja in kaj se je izboljšalo znotraj podjetja, v kolikor se le je? (večja produktivnost, boljša sledljivost, nižji stroški, znižanje zalog, nižje število nizko kvalificiranih, itd.)

11. Ali uporabljate tehnologije Industrije 4.0 skozi celotno tovarno (lokacijo)? Če ne, prosim da naštejete na katerih oddelkih lahko le to zasledimo in pa zakaj samo tam? Kako bi ocenili znanje o Industriji 4.0 glede na oddelek?

12. Vidite implementiranje industrije 4.0 v vašem podjetju kot velik izziv? Ali ste imeli kakšne težave in katere?

13. Kako imate poskrbljeno za podatkovno/kibernetsko varnost?

14. Ali podatke, ki jih beležite, ponovno uporabite? Zakaj?

15. Kako pomembna je za vas analiza podatkov potrošnikov?

16. Kateri so ključni indikatorji, ki jih uporabljate za spremljanje napredka Industrije 4.0?

17. Ali menite, da pri implementaciji Industrije 4.0 pride do odvečnega kadra, saj le tega nadomestijo novodobne tehnologije?

18.Če menite, da bo prišlo do zgoraj omenjene situacije (odvečnega kadra), kaj boste naredili z odvečnim kadrom? Ste pripravljeni le te izobraziti, ter jih po razporediti po podjetju?

19. Katere izmed že zgoraj omenjenih tehnologij so ključne, da ostanete konkurenčni v vaši branži?

20. Ali ste pri implementaciji pridobili kakršnekoli subvencije? Katere?

21. Ali menite, da je industrija 4.0 dan danes ključ do uspešnejšega poslovanja? Zakaj?

22. Ali bi še sami kaj dodali, vezano na uporabo tehnologije ali Industrijo 4.0 v podjetju?

Appendix 3: Questionnaire for the HR position in Slovenian language

Vprašalnik

Spoštovani, pred vami je vprašalnik, ki sva ga pripravila študenta Miha Povšin in Rok Primožič iz Ekonomske fakultete v Ljubljana. Vprašalnik je namenjen opravljanju analize na temo industrija 4.0 in bo uporabljena pri pisanju magistrske naloge. S pomočjo vaših odgovorov bomo lažje ovrednotili trenutno stanje vašega podjetja in nato podali predloge za izboljšave. Že vnaprej se vam zahvaljujemo za odgovore.

Ime podjetja:
____

Panoga, v kateri se nahaja podjetje:
____

Velikost podjetja (mikro/makro in pa število zaposlenih na trenutni lokaciji):
____

Glavna dejavnost podjetja:
____

1. Vaša pozicija oziroma naziv v podjetju?

2. Kaj za vas predstavlja pojem Industrija 4.0?

3. Kako bi ocenili trenutno stopnjo Industrije 4.0 v vašem podjetju glede na zgornjo definicijo? (Govorimo: nismo še prisotni, začetniki, delno digitalizirani, napredno digitalizirani ali šampioni v digitalizaciji)

4. Vidite implementiranje industrije 4.0 v vašem podjetju kot velik izziv? Ali ste imeli kakšne težave in katere? (pri zaposlovanju kvalificiranega kadra)

5. Ali menite, da pri implementaciji Industrije 4.0 pride do odvečnega kadra, saj le tega nadomestijo novodobne tehnologije?

6. V kolikor menite, da bo prišlo do zgoraj omenjene situacije (odvečnega kadra), kaj boste naredili z odvečnim kadrom? Ste pripravljeni te delavce izobraziti, ter jih po razporediti po podjetju?

7. Kako vpliva implementacija industrije 4.0 na vaše področje(HR)?

8. Primer kompetenc, ki opredelijo posameznika kot kvalificiranega delavca znotraj Industrije 4.0?

9. Kateri kader je najpogosteje iskan oziroma katerega je težko dobiti?

10. Ali sodelujete z razvojnimi inštitucijami?

11. Menite, da je malo kadra dovolj izobraženega, ko stopi iz študija v službo?

12. Ali uporabljate umetno inteligenco v procesu zaposlovanja?

13. Ali bi še sami kaj dodali, vezano na uporabo tehnologije ali Industrijo 4.0 v podjetju?

Appendix 4: Questionnaire for the HR position

Dear Sir or Madam, the questionnaire was prepared by students Miha Povšin and Rok Primožič from the School of Economics and Business. The questionnaire will later be used for an analysis of Industry 4.0 and will be included in the master's thesis. With the help of your answers, we will find it easier to evaluate the current state of your company and then make suggestions for improvements. Thank you in advance for your answers.

Company name:

____

Industry, in which the company operates:

____

Company size (micro/macro and number of employees):

____

The core activity of the company:

____

1. Your position or title in the company?

2. What does the term Industry 4.0 mean to you?

3. How would you rate the current Industry 4.0 level in your company according to the above definition? (Speaking: not yet present, beginners, partially digitized, advanced digitized or champions in digitization)

4. Do you see implementing Industry 4.0 in your company as a big challenge? Did you have any problems and which ones? (when hiring qualified staff)

5. Do you think that there will be redundant staff with the implementation of Industry 4.0, as workers will be replaced by modern technologies?

6. If you think the above situation (redundant staff) will occur, what will you do with the redundant staff? Are you ready to educate them and distribute them around the company?

7. How does Industry 4.0 implementation affect your field (HR)?

8. An example of competencies that define an individual as a skilled worker within Industry 4.0?

9. Which staff is most often sought after, or which is difficult to get?

10. Do you work with development institutions?

11. Do you think that only a small number of employees is educated enough when they step out of school to work?

12. Do you use artificial intelligence in the recruitment process?

13. Would you like to add something related to the use of technology or Industry 4.0 in the company?

Appendix 5: Questionnaire for the technical position

Questionnaire

Dear Sir or Madam, the questionnaire was prepared by students Miha Povšin and Rok Primožič from the School of Economics and Business. The questionnaire will later be used for an analysis of Industry 4.0 and will be included in the master's thesis. With the help of your answers, we will find it easier to evaluate the current state of your company and then make suggestions for improvements. Thank you in advance for your answers.

Company name:

____

Industry, in which the company operates:

____

Company size (micro/macro and number of employees):

____

The core activity of the company:

____

1. Your position or title in the company?

2. Who are your key customers / do you also do business with foreign customers?

3. What does the term Industry 4.0 mean to you?

4. How would you rate the current Industry 4.0 level in your company according to the above definition? (Speaking: not yet present, beginners, partially digitized, advanced digitized or champions in digitization)

5. If you are at least a beginner, please indicate which of the following technologies you already use and which you want to implement within 3-5 years?

	Which of the following technologies are you already using?	Which of the following technologies will you start using in the next 3-5 years?
3D printing		
Additive production / modularization		
Augmented Reality (AR) / Virtual Reality (VR)		
Use and analysis of big data		
Cloud Computing		
Blockchain		
Internet of Things (IoT)		

Radio Frequency Identification (RFID)		
Use of robots		
Automated production		
Computer Process Control (CPM)		
Customer Relationship Management (CRM) system		
Digitized warehouse		
Enterprise Resource Planning (ERP) system		
Use of smart mobile devices in business processes		

6. Why did you start, or you would start with the implementation of the above technologies, which cover the area of Industry 4.0 (it has an impact on the company or the acquisition of the business, due to customer requirements, competition, optimization etc.)?

	I don't agree at all	I disagree	I partly disagree	Neither	I partly agree	I agree	I totally agree
... we think this would increase our efficiency.							
... we expect this to lower the cost of our business.							
... we believe this would simplify our business.							
... we believe this would lower the cost of transactions with our business partners.							
... we want to be seen as a very professional company							

7. Do you think technology is changing the markets in which your business operates?

8. If you answered YES to the question above, please explain how it affects it and what changes are visible? And what consequences does it have on your company?

9. Evaluate your level of agreement with the statements below.

	I don't agree at all	I disagree	I partly disagree	Neither	I partly agree	I agree	I totally agree
We don't trust I4 technology							
I'm afraid of dependence on I4 technology							
Our employees do not support I4							

I'm afraid of disclosing data because of I4							
Our overall experience with I4 technology is very positive							
We are very pleased with our I4 technologies							
If we had to, we would again decide to implement the same I4 technologies							
We are satisfied about our implementation of I4 technologies							

10. Now that you have been involved in Industry 4.0 for quite some time, can you list which areas and what has improved within the company, if any? (higher productivity, better traceability, lower costs, lower inventories, lower number of low-skilled, etc.)

11. Do you use Industry 4.0 technologies throughout the factory (location)? If not, please list in which departments they are present and why only there? How would you assess the knowledge of Industry 4.0 by department?

12. Do you see implementing Industry 4.0 in your company as a big challenge? Did you have any problems and which ones?

13. How are data-security / cyber-security taken care of?

14. Do you reuse the data you gather? For what purpose?

15. How important is consumer data analysis to you?

16. What are the key indicators you use to monitor the progress of Industry 4.0?

17. Do you think that there will be redundant staff with the implementation of Industry 4.0, as workers will be replaced by modern technologies?

18. If you think the above situation (redundant staff) will occur, what will you do with the redundant staff? Are you ready to educate them and distribute them around the company?

19. Which of the above technologies are key to staying competitive in your industry?

20. Did you receive any subsidies during the implementation? Which ones?

21. Do you think Industry 4.0 is the key to more successful business today? Why?

22. Would you like to add something related to the use of technology or Industry 4.0 in the company?