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POLICY RESPONSES TO THE CHALLENGES OF THE FOURTH INDUSTRIAL REVOLUTION

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AUTHORSHIP STATEMENT

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LIST OF ABBREVIATIONS

3D – Three-dimensional
4G – Fourth-generation broadband cellular network
5G – Fifth-generation broadband cellular network
AI – Artificial intelligence
CEDEFOP – European Centre for the Development of Vocational Training
Cobot – Collaborative robot
COVID-19 – Coronavirus disease 2019
CRISPR – Clustered regularly interspaced short palindromic repeats
FAA – Federal Aviation Administration
FTTH – Fibre-to-the-home
GDP – Gross domestic product
ICT – Information and communication technology
IoT – Internet of Things
IT – Information technology
NFC – Near field communication
R&D – Research and development
RAMI 4.0 – Reference Architectural Model for Industry 4.0
RFID – Radio frequency identification
RRI – Robot Revolution Initiative
S4 – Smart Specialization Strategy
SME – Small and medium-sized enterprise
SRIP – Strategic research and innovation partnership
STEM – Science, technology, engineering and mathematics
UNESCO – United Nations Educational, Scientific and Cultural Organisation

INTRODUCTION

The Fourth Industrial Revolution is bringing about rapid technological advances that promise to be one of the key drivers of the economy and have the ability to, in the long term, vastly improve the well-being of people and households as well as increase the effectiveness and efficiency and thus the global competitiveness of an economy. It is poised to have a profound multifaceted set of impacts on the economy and society at large (Schwab, 2017). Many will be positive, whilst others will have negative consequences. It is imperative for policymakers to rise to the challenge and address these issues through policy in order to maximize benefits and effectively mitigate any negative effects.

We explore the implications of the Fourth Industrial Revolution on the economy and society at large, as well as address the question of how Slovenia is tackling the challenges brought about by the Fourth Industrial Revolution through policy responses.

We have expanded these two issues into six research questions, addressed in the thesis:

1. Will the Fourth Industrial Revolution increase overall productivity?
2. Will the Fourth Industrial Revolution have divergent effects on job demand?
3. Will educational systems be affected by the Fourth Industrial Revolution?
4. Will the Fourth Industrial Revolution increase the importance of digital security?
5. Are comprehensive strategies more successful at addressing the impacts of the Fourth Industrial Revolution than individual responses?
6. Does Slovenia require to adjust its current policies to successfully tackle the Fourth Industrial Revolution?

In order to address these research questions, we first aim to define the Fourth Industrial Revolution and Industry 4.0 and discuss the drivers of the revolution. We then discuss in detail the impacts of these drivers in four main policy areas: productivity, the labour market, education and digital security. These areas are poised to see some of the largest changes in the coming years. In addition to the four main policy areas, we also discuss selected other impacts. Furthermore, we discuss each of the impacts through policy responses, either implemented, in the process of implementation or proposed. To stress the complex multitude of impacts single innovations, technological breakthroughs and drivers can have on these policy areas, we present a case study of last yard delivery innovations through the lens of their impacts on the described four main policy areas.

Responses by policy area should not be viewed individually but must be part of a comprehensive policy mix. Therefore, we attempt to understand how five developed countries with high robot densities (Austria, Denmark, Germany, Japan and Singapore) are dealing with the discussed issues both separately and comprehensively as well as analyse their Fourth Industrial Revolution-related strategies to identify best practices. We synthesize these findings and apply them to the case of Slovenia, as well as discuss the formulation of an appropriate policy mix for Slovenia by reviewing other solutions and their implementations.

The chosen method is an explanatory study, using multi-method qualitative research. We research and assess the impacts of the Fourth Industrial Revolution along with the corresponding policy responses for the five categories through critical literature review. We gather the data and information first and foremost through secondary sources, e.g. articles in scientific journals and research papers. In order to research both successful and unsuccessful implementations and practices in countries that experienced the Fourth Industrial Revolution heretofore, we conduct a multiple case study on five countries: Austria, Denmark, Germany, Japan and Singapore.

1 FOURTH INDUSTRIAL REVOLUTION

Industrial revolutions have propelled humankind into the modern era. However, while previous revolutions liberated humans from animal power, introduced mass production and brought digitalization to the masses, the Fourth Industrial Revolution will be very different. It has the potential to bring about technologies that will connect digital, biological and physical worlds, influence all industries and perhaps even challenge our existing deepest-held philosophical notions about humanity (Grinin & Grinin, 2014).

Throughout history, technological progress often encountered some form of resistance and backlash. Automation has been one such particular target over two centuries, with the first protest movements appearing in the early 19th century, intent on destroying the machines that were stealing their jobs. In the 1950s and 1960s, concerns over automation and the joblessness it would cause prompted the United States government to form a national commission to study the growth of productivity and its potential to outstrip demand for labour. The commission's conclusion was that automation did not in fact eliminate work, but jobs instead (Bowen, 1966). Brynjolfsson and McAfee (2014) have echoed similar arguments, arguing that technological progress will leave behind some people, mostly with ordinary skills, as robots and computers increasingly acquire these skills, thus having their jobs automated away. The advent of the Fourth Industrial Revolution has therefore reignited anxieties about automation and its impact on society (Akst, 2013).

In its essence, the Fourth Industrial Revolution refers to the widespread adoption of new technologies and practices such as robotics, automation, artificial intelligence, autonomous machines, three-dimensional (hereinafter: 3D) printing, the Internet of Things (hereinafter: IoT), nanotechnology, biotechnology, as well as the rapid advancements in materials science, energy storage and quantum computing (Schwab, 2017). Although many of these are still in their infant stages, they are already proving to be revolutionary (Schwab, 2017). Digital technologies, grounded in computer hardware, software and networks are not a new phenomenon but are becoming increasingly refined and integrated into business processes and are thus changing society and the economy. According to Brynjolfsson and McAfee (2014), society is facing a second machine age. The present time is an inflection point precisely because of maturing computer technologies and the exponentially growing processing power and its availability in terms of cost. Similarly, the cost of storing and transmitting information has declined sharply, allowing new business models that were unfeasible in the already digital past. The cost of storing a gigabyte of data is below 0.03 US dollars per year, whereas it stood at 10,000 US dollars per year twenty years ago (Schwab, 2017).

The changes coming about as part of the new industrial revolution are not only fast but also highly efficient and effective with an increasing output per unit of labour. For example, in 1990, the three largest corporations in Detroit, a hub of the automotive industry posted revenues of 250 billion US dollars while employing 1.2 million workers. Conversely, in 2014, the three largest corporations in Silicon Valley posted revenues of a similar amount (247 billion US dollars) while employing about a tenth of the number of workers (Manyika & Chui, 2014).

1.1 Drivers of the Fourth Industrial Revolution

The development and progress behind the Fourth Industrial Revolution can be roughly divided into three categories of so-called “megatrends”. These technological drivers are biological, physical and digital, with the latter two being considered the basis for the new industrial paradigm (Schwab, 2017). The concurrent and combined use of advanced technologies promises to blur the boundaries of the physical, digital and biological world, and introduce a new era of connected technologies. A breakdown of the innovation and breakthroughs in these respective fields can help provide a better understanding of the importance and impacts of these drivers on the emergence of Industry 4.0. Unlike in the Third Industrial Revolution, where the majority of innovation was in the physical world, the Fourth Industrial Revolution is predominantly characterized by software solutions, i.e., inventions in the digital world (Schwab, 2017).

1.1.1 Digital drivers

In light of the fact that innovations introduced in the era of the Fourth Industrial Revolution are largely enabled and powered by the digital sphere, it is reasonable to assume that digital drivers are fundamental and a base platform for the coming changes. The main technological drivers are IoT; artificial intelligence, robotics and machine learning; big data and cloud computing; and digital platforms (Li, Hou & Wu, 2017).

Establishing a network of physical components equipped with electronics and sensors enables intercommunication, data collection and automated or, in certain cases, autonomous responses. Devices with such properties fall in a product category dubbed IoT. The International Telecommunication Union (2012) defines IoT as a global infrastructure for the information society, enabling advanced services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies. It is essential for the future construction of information, network, and communication technology. If the Internet introduced and popularized human-to-machine communication, where we were previously only limited to human-to-human communication, the Internet of Things brought forth the possibility of machine-to-machine communication (Tan & Wang, 2010). By 2020, there will be an estimated 20 billion interconnected IoT devices supporting business operations, used as household appliances, and even acting as integral parts of smart cities. Optimistic projections show that the network of IoT devices could see a fivefold increase by 2025, which translates to a global economic impact of more than 11 trillion US dollars (Attia, 2019). Integrating and connecting wired and wireless objects enables these devices a capability to exchange information, identify and monitor situations, and, most importantly, respond and take actions accordingly in the absence of human intervention.

Artificial intelligence (hereinafter: AI) focuses on employing mechanisms, which can generate intelligence and cognitive abilities and is at the core of many other digital drivers, including IoT and robotics (West & Allen, 2018). While the field of AI is still relatively new and far from being a valid substitute for human intelligence, innovators and scientists aim to use AI to bring human-like cognitive abilities and decision making to machines. A niche subset of AI, commonly referred to as Machine Learning utilizes and processes large amounts of available existing data to learn from previous resembling experiences, foresee situations in advance and act accordingly. The ability to learn and adapt is what makes a system operating in an uncertain setting intelligent, and allows it to develop features and functionalities which are superior and broader in scope than those that were originally designed by the developers (Alpaydin, 2016). The inspiration and guidance in developing such systems comes from the human brain. While inferior in storing large amounts of data, it surpasses man-made systems in several aspects, including vision, speech recognition and learning, amongst others. It is estimated that AI could reach the level of brain complexity by 2040 (Müller & Bostrom, 2014). According to Google Director of Engineering Ray Kurzweil (in Reedy, 2017), this could also enable the creation of a backup copy of a human brain.

Connected devices, digital systems, artificial intelligence and information technology as a whole all have in common one thing – they are reliant upon massive volume of data and leave behind a digital trace (Marr, 2015). The term “Big Data” refers to exponentially growing quantities of structured or unstructured data which, once processed and analysed, enables intelligent decision making, and in certain cases, even act as a source of competitive advantage (Bahga & Madisetti, 2014). Data processing does not stop at the business level, though. Blockchain, a new, radical way of recording data resorts to a distributed network of connected computers to process and anonymously document financial transactions onto a digital ledger, publicly available for any interested party. As it uses cryptography to ensure immutability, it is considered impossible to corrupt (Carlozo, 2017). As a platform, it enables monetary transactions which bypass all financial institutions and thus allow for anonymous and safe peer-to-peer transactions, a trend gaining in popularity as a response to falling confidence in conventional financial institutions (Mandeng & Velissarios, 2019).

Another factor of differentiation from traditional financial institutions lies in its lack of a central point of authority. The most widely adopted digital currency utilizing Blockchain technology, Bitcoin, currently processes more than 300,000 transactions per day (Blockchain.com, n.d.). Exponential growth of big data comes at a cost of larger computing power requirements for data processing and analysis. This is in part made possible through cloud-based solutions, more particularly, cloud computing. Cloud computing describes an on-demand, shared access to a network of computing resources, that can be enabled or disabled in a relatively short amount of time and with minimal management and service provider interaction (Ruparelia, 2016). Unlike locally available hardware, e.g., individual servers or data centres, cloud services are available to everybody, regardless of their location and makes it possible to conduct big data analysis without the need for a physical infrastructure.

Lastly, online platforms and marketplaces connecting millions of users on one side and a supply of available services on the other introduce a new subset of the economy, referred to as sharing- or on-demand economy. Unlike with centralized institutions, the supply of labour and capital on these platforms is largely “crowd-based”, i.e., distributed or centralized through individuals (Sundararajan, 2016). Participants oftentimes act both as a customer and an employee, though employment differs from traditional employment in that the recruitment requirements are much lower and that it is, in most cases, on a contract work level basis. Examples of such platforms include ride-hailing platform Uber and property-renting platform Airbnb. As Goodwin (2015) points out, the former does not own any vehicles and the latter does not own any properties. By allowing and enabling anyone with a vehicle and a driver's license the ability to become a professional driver, Uber has caused a fair amount of controversy as it significantly disrupted the taxi market (Cramer & Krueger, 2016).

1.1.2 Physical drivers

Physical drivers are drivers that are characterized by their direct impact on our daily lives and include 3D printing, autonomous machines, advanced robots and new materials

(Schwab, 2017). Development of digital and sensor technology along with new materials allowed for the introduction of new, interconnected intelligent factories. Using network technology, monitoring equipment, and IoT, the “smart factory” is able to plan, monitor, evaluate, perform automatic error diagnosis as well as learn and act through a retrospective of past activities in order to self-improve its manufacturing with time (Karabegović, 2018).

The most dominant modern technology and the key driver behind the Fourth Industrial Revolution is robotics and automation. Though popularized mainly through production lines of the automotive industry in 1960s, the use of robots grew far beyond manufacturing to everyday life. Today, robots are used for entertainment, education, training, security and military, agriculture, food preparation, surveillance and human augmentation, and in the majority of these cases, robots are inherently intertwined with artificial intelligence (Sheridan, 2016). Using machine learning, modern robots are capable of activities far more advantageous than their early counterparts. Unlike robots in the past, which were limited to a predetermined and preprogramed set of thought processes, movements and actions, AI-leveraging robots are able to continuously learn, react autonomously and improve their efficiency (Perez, Deligianni, Ravi & Yang, 2016).

Practical application of artificial intelligence can be found in autonomous vehicles, where AI assumes a role of processing massive amounts of vehicle-generated data and using complex algorithms for route planning, vehicle navigation and, most importantly, potential accident prevention (Bagloee, Tavana, Asadi & Oliver, 2016). Though the first use case that usually comes to mind when discussing autonomous vehicles are self-driving passenger cars, certain businesses and industries are already embracing autonomous vehicles in their daily operations, such as using autonomous drones and self-driving trucks for parcel delivery. While legislation regarding autonomous vehicles is still in its early development stage, the concept is already showing a significant potential for improvement in congestion release, fuel efficiency, enabling mobility to those unable to drive and in reduction of road accidents (Bagloee, Tavana, Asadi & Oliver, 2016). The latter seems counterintuitive at first, knowing that the driver is not in full control, but the lack of human error should not be underestimated. The main reason for this is that programmed autonomous vehicles inherently drive differently than their human counterparts. Their reaction time is faster, they do not use alcohol and recreational drugs and most importantly, they never intentionally break the law (Fagnant & Kockelman, 2015). In practice, this means that the roads are safer for all participants and the traffic is more efficient as standardization of driving could potentially be perfectly organized.

Another innovative technology shaping the industry is 3D printing. Using the transformative approach of adding layers of material, 3D printers are principally used for producing cost effective prototypes and minor parts. Unlike conventional material processing which works largely through cutting, shaping and removing material, 3D printing is quite the opposite at its core. It disrupted several different industries including automotive, education, mechanics, space, medical and even food industry, just to name a few. Individual products cost more than their mass-produced counterparts however, it is in the ability to customize, adjust and change the outcome without the requirement for new expensive sets of tools, where 3D printing truly excels. Having been around since the 1980s, 3D printing is not an entirely new concept in manufacturing, but its increasing use in the medical devices and food industries proves the technology is here to stay (Schwab, 2017).

1.1.3 Biological drivers

Biological drivers are drivers that are characterized by innovations in the field of genetic engineering, nanotechnology, neurotechnology and the increased use of technology in medical procedures (Schwab, 2017).

An innovation in biotechnology which affects research, development and testing of new medicine are organs-on-chips. These state-of-the-art miniature models of human organs in the form of a USB stick allow researchers to simulate effects on biological mechanisms and receive realistic results without any actual interaction with a living organ. In practice, this means that it is possible for lab technicians to observe a cellular response to an infection without exposing a living human body to any risk. Some examples of these include a miniature model of a liver, kidney, heart and lung, though they are predominantly still in testing (Al-Rodhan, 2016). A related technological development are artificial organs. Unlike organ models, whose use is limited to research and experiments, artificial organs are designed to be used in medical procedures involving humans. These are not only an alternative to human organs, but also an opportunity to explore beyond what is possible today, e.g., artificial womb which works irrespective of age or even gender (Grinin & Grinin, 2014).

One of the potentially biggest breakthroughs in science are clustered regularly interspaced short palindromic repeats (hereinafter: CRISPR). In simple terms, CRISPR is a recently developed tool which makes it possible to manipulate DNA sequences and doing so modify gene functions (Vidyasagar, 2018). Technology champions believe CRISPR has the potential to improve faults in human genetics, such as genetic deafness, contribute towards curing fatal diseases, e.g. AIDS or cancer, create more powerful antibiotics and significantly revolutionize the food industry (Plumer, Barclay, Belluz & Irfan, 2018). Some examples of modifications in agronomy include drought-tolerant or above average yield crops, removing defective genes from livestock, making hypoallergenic eggs or making wheat immune to fungi or low-gluten by nature (Mah, 2019). It is not without drawbacks, however. The emergence and increased popularity of CRISPR raised many potential issues, among others a theoretical possibility to create a “superhuman” race. The line between what is ethically acceptable and what is not is thin, as CRISPR makes it possible to introduce immunity to fatal diseases but also a potential for genetically modified individuals with desired visual traits or even superior abilities (Plumer, Barclay, Belluz & Irfan, 2018).

However, overcoming the limits of the human body is not restricted to genetic modification. Using physical and cognitive enhancement, such as comprehension-boosting drugs, bionic retinal implants and artificial limbs; memory, concentration, sensory perception and mobility can be improved. The ability to influence the competence and inclination to learn and accomplish tasks, reduce work-related illness, and quicken the recovery time from injuries and illnesses has the potential to considerably change the workforce of the future (Academy of Medical Sciences, 2012). Widely known and used methods of cognitive enhancement include drugs otherwise used for treatment of attention deficit hyperactivity disorder. Battleday and Brem (2015) found that the prescription drug Modafinil not only helps with sleep disorders, but also temporarily enhances the cognitive abilities of an individual, especially in the case of lengthy tasks which require extensive amount of focus and concentration. Considerable potential for such improvements lies particularly in professions, in which work involves responsibility for the safety of others, e.g. airline pilots or bus drivers (Ach & Lüttenberg, 2002). Moreover, human enhancement represents an opportunity for individuals with disabilities to return to their normal lives or experience what is considered normal life for the first time For example, using electric devices which attach to the auditory nerves, individuals with partial or even complete hearing impairment can be made to hear and can assume work roles they could not beforehand (Agar, 2013) It has not gone without a healthy amount scepticism, though. Even though experts generally welcome initiatives to assist individuals with disabilities, some are worried what could happen if these enhancements were taken to radical extents. Considering the previous example, if it is possible to achieve similar hearing abilities to that of healthy individuals, it is theoretically likewise possible to empower individuals with hearing abilities beyond natural (Agar, 2013). Similarly, enhanced workers can work longer than their counterparts, which can potentially delay the retirement of aging workforce.

1.2 Industry 4.0

The transition to new technologies and new ways of producing things and doing business bears importance for the competitive position of countries in global markets; therefore, some government-led initiatives have been introduced around the world to support these transitions (Rojko, 2017). The first large-scale initiative among governments was Industry 4.0, which emerged as a concept within the context of the Fourth Industrial Revolution in 2011 in Germany to describe the ongoing revolution in the organisation of global value chains (Schwab, 2017). According to the Federal Ministry for Economic Affairs and Energy (2016), Industry 4.0 represents a paradigm shift. Manufacturing and services distinctions will fade, while competitive advantage in manufacturing will be driven by digital factors and information and communication technologies (hereinafter: ICT). The principle of Industry

4.0 is thus to make use of the potential of new technologies and concepts such as (Rojko, 2017):

- the widespread availability and use of reliable and cheap internet connections and the Internet of Things,
- the integration of technical processes and business processes in companies,
- business process connections across company borders,
- digital mapping and virtualisation of reality,
- smart factories with smart means of industrial production and smart products.

1.2.1 Smart factory and cyber-physical systems

One of the core concepts of the Industry 4.0 initiative is the so-called "smart factory". A factory is considered smart when it is characterised by its adaptability, resource efficiency and ergonomics as well as the integration of its customers and external partners in business and value processes (Hughes, 2017).

Table 1: Comparison of current factories with smart factories

	Data source	Current factory		Smart factory	
		Attributes	Technologies	Attributes	Technologies
Component	Sensor	Precision	Smart sensors and fault detection	Self-aware Self-predict	Degradation monitoring & remaining useful life prediction
Machine	Controller	Producibility & performance	Condition-based monitoring & diagnostics	Self-aware Self-predict Self-compare	Uptime with predictive health monitoring
Production system	Networked system	Productivity & Overall equipment effectiveness	Lean operations: work and waste reduction	Self-configure Self-maintain Self-organize	Worry-free productivity

Source: Lee, Bagheri & Kao (2015).

Table 1 compares current factories with the smart factory concept of Industry 4.0. The core process in a smart factory is the conversion from digital to physical in a reconfigurable manufacturing system. This represents an advance over flexible production lines, where machines are programmable and allow the production of different products but offer no flexibility in production capacity, which in turn were an innovation over fixed production lines, where machines could perform specific tasks that resulted in the capability to produce a single product (Dhar, 1989). On the other hand, reconfigurable manufacturing systems can adapt their hardware and software components to follow changing requirements of type and quantity of the products. The interoperability and interconnectivity of machines are necessary prerequisites for the efficient functioning of cyber-physical systems. The continuous flow of data requires machine-to-machine communication via the Industrial Internet of Things. Furthermore, human-to-machine collaboration is essential as some tasks will remain too unstructured to be fully automated (Rojko, 2017).

The basic building block of the smart factory are cyber-physical systems, a collection of computing devices communicating with each other and interacting with the physical world through sensors and actuators in a feedback loop (Alur, 2015). These computing devices are a generalisation of embedded systems, that is physical systems integrated with ICT components (Rojko, 2017). Cyber-physical systems represent transformative technologies for managing interconnected systems between their physical machines and computational capabilities (Baheti & Gill, 2011). With the continuing increase in the affordability and availability of sensors, data acquisition systems, computer networks and other similar technologies, market forces require that ever more factories move toward the implementation of high-tech methodologies (Lee, Bagheri & Kao, 2015). The result of the ever-growing use of sensors and networked machines is a continuous generation of high-volume data that may be analysed computationally to reveal patterns, trends and associations, known as big data (Lee, Lapira, Bagheri & Kao, 2013). Programmable machines are typically used with a large share of mobile agents and robots able of self-organisation and self-optimisation (Rojko, 2017).

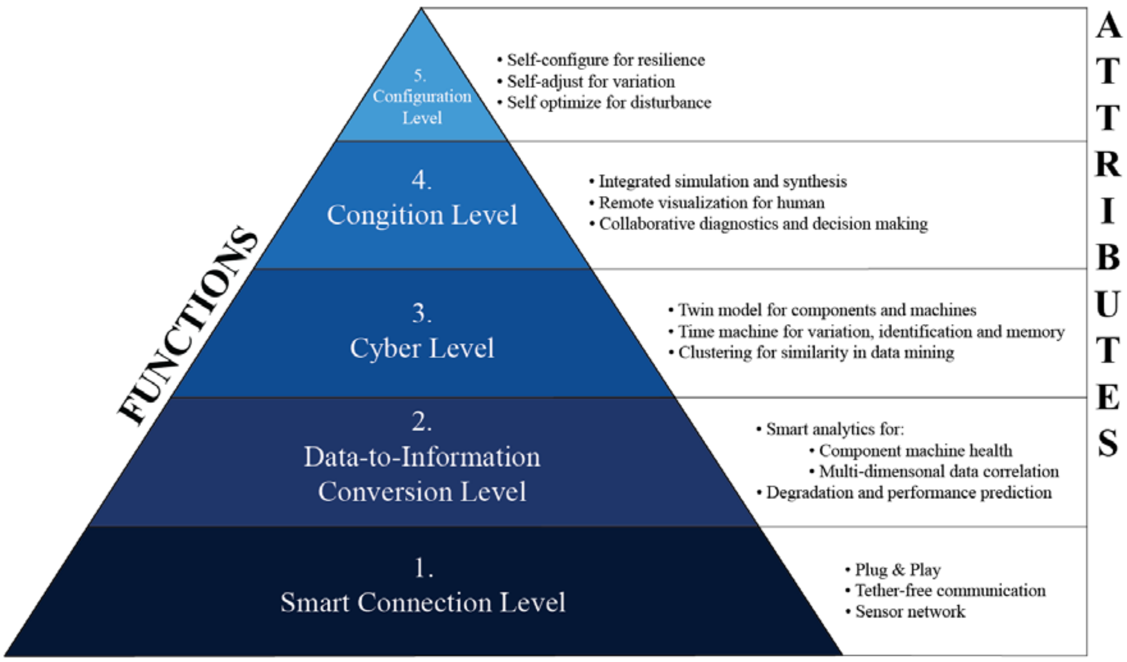
Cyber-physical systems, integrated with production, logistics and services, promise to transform current factories into smart factories with a significant economic potential. According to Bitkom and Fraunhofer IAO (2014), the value added by Industry 4.0 to the German economy could reach 78.77 billion euro by 2025, which represents additional growth of 1.7 percentage points per annum. Lee, Bagheri & Kao (2015) proposed a five-level “5C” structure of cyber-physical systems development for use in manufacturing. As shown in Figure 1, the architecture is composed of the following levels (Lee, Bagheri & Kao, 2015):

- Smart connection level, the acquisition of accurate and reliable data through sensors. Two important factors to consider at this level are the requirement for seamless and tether-free communication and the type and specification of sensors. The aim of this level is effective condition monitoring.
- Data-to-information conversion level, the inference of meaningful information from data. Through the calculation of metrics such as health values or estimated remaining useful times, this level brings “self-awareness” to machines.
- Cyber level, the central information hub of the five-level architecture. Massive information collection enables analytical processes that can be used to provide a better

insight into the status of individual machines and their performances compared to the rest of the network. Furthermore, machine performance can be compared to historical information to predict the machinery's future behaviour.

- Cognition level, the generation of thorough knowledge of the monitored system with a presentation of the acquired knowledge to users to support decision-making. The usage of appropriate information display techniques is crucial to effectively transfer knowledge to users and enable decision prioritisation and optimisation.
- Configuration level represents the feedback from cyberspace to the physical space and acts as supervisory control to make machines self-configurable and self-adaptive. Corrective and preventive decisions made based on the information gathered from the cognition level are applied to the monitored systems at this level.

Figure 1: Five-level 5C architecture of cyber-physical systems



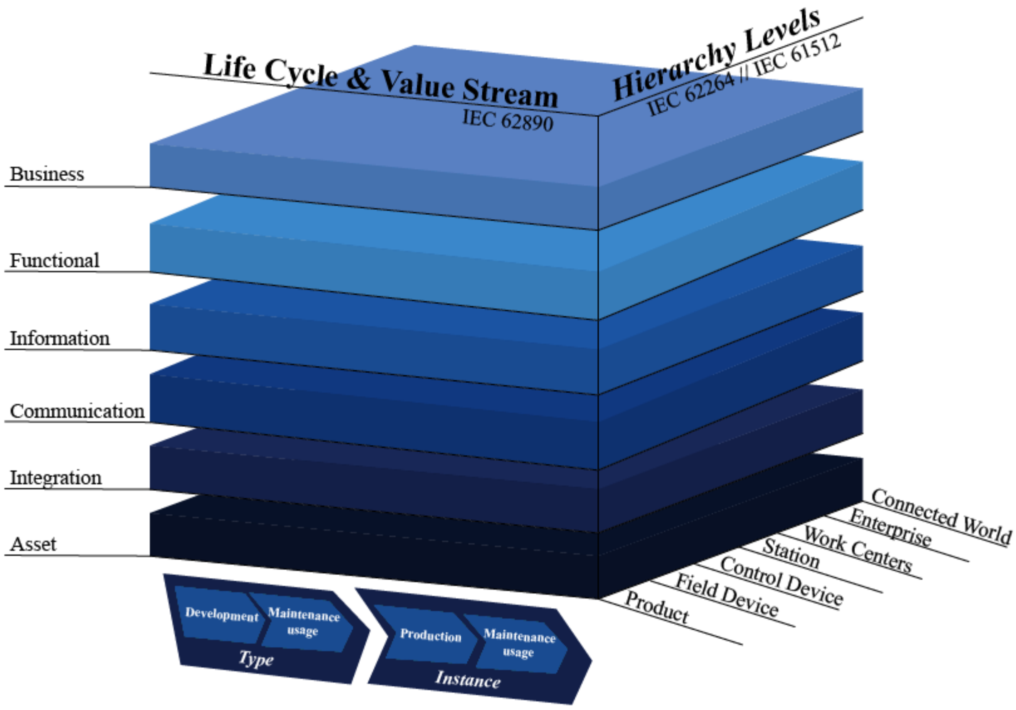
Source: Lee, Bagheri & Kao (2015).

1.2.2 Reference Architectural Model for Industry 4.0

The Reference Architectural Model for Industry 4.0 (hereinafter: RAMI 4.0) was developed by the German Electrical and Electronic Manufacturers' Association to support Industry 4.0 initiatives (Lydon, 2019). It is a flexible service-oriented architecture framework combining services and data to facilitate and promote the main aspects of Industry 4.0 (Industrial Internet Consortium, 2017). The Industry 4.0 concept will be applied in most companies through the use of existing equipment and technologies, it is only when a new production system is planned that there is an opportunity to design the system from scratch according to Industry 4.0 principles (Rojko, 2017). The added value of the reference model is in addressing the challenge of how to integrate existing standards into the new system as well as providing a common perspective that allows participants to develop a common understanding of the concepts and implications of Industry 4.0.

RAMI 4.0 is a three-dimensional meta model based on the Smart Grids Architecture Model, which should enable the identification of existing standards, closure of gaps and loopholes in existing standards and the identification of overlaps in existing standards (Rojko, 2017). As the model's usefulness increases if it is applicable to a wide range of industries, the model enables an analysis of production systems from different aspects. The three dimensions or axes represent different manually interconnected features of the technical-economical properties of systems (Zezulka, Marcon, Vesely & Sajdl, 2016).

Figure 2: Reference Architectural Model for Industry 4.0



Source: Federal Ministry for Economic Affairs and Energy (2018).

The RAMI 4.0 model and its three dimensions are graphically depicted in Figure 2. The vertical axis is composed of functional layers and represents different aspects, specifically the business, functional, information and communication aspects, as well as the integration ability of assets. This corresponds to information-technology (hereinafter: IT) thinking, where complex projects are split up into clusters of manageable parts (Federal Ministry for Economic Affairs and Energy, 2018). The base layer is an assets layer, which includes physical components, such as machines and robots as well as non-physical objects such as software as well as human capital. An integration layer presents information on assets in a machine-readable or digitally-processable form. It contains elements which are connected to ICT such as radio-frequency identification (hereinafter: RFID) readers, sensors, human-machine interface etc. A communication layer functions as a standardisation layer using uniform data formats and predefined protocols. An information layer processes and integrates available data into useful information. A functional layer enables formal description of functions and creates a platform for horizontal integration of various functions, including enabling enterprise resource planning. Finally, a business layer ensures the integrity of functions in the value stream and includes mapping of the business model and links between different business processes (Rojko, 2017; Zezulka, Marcon, Vesely & Sajdl, 2016).

The left-hand horizontal axis of the RAMI 4.0 model represents the product life cycle and value streams. Dependencies such as constant data acquisition throughout the life cycle can be represented through the chronological or life cycle-oriented division of the dimension into two elements, type and instance. Type refers to the concept of the product from ideation to series production, whereas instance refers to each individual produced instance of the product. Feedback on individual instances reported back to the manufacturer can lead to an amendment of the type, ensuring that the type can be updated subject to usage and feedback. Digitisation and the linking of value streams can provide a great potential for improvement (Federal Ministry for Economic Affairs and Energy, 2018; Rojko, 2017). The life cycle can therefore be viewed with value-adding processes that it contains and not in isolation as it is viewed presently (Zezulka, Marcon, Vesely & Sajdl, 2016).

Finally, the right-hand horizontal axis represents the location and functional hierarchy from the product to the connected world as the last stage of Industry 4.0 development. The location of specific functionalities and responsibilities represents a functional hierarchy and not equipment classes or hierarchical levels of a classical automation pyramid. The issue is thus functional assignment and not implementation. Within the context of Industry 4.0, the implications go beyond the control device to within the machine or system. Furthermore, it is not just the facility and machinery that is important in a production process, but the product itself is as well. At the top level, the RAMI 4.0 model goes further than the facility and includes groups of facilities, the collaboration of external organisations, suppliers and customers and beyond (Rojko, 2017).

The RAMI 4.0 model can therefore be considered to significantly alter the current pyramidal factory hierarchy, where the main structure and functions are defined by hardware and communication flows strictly hierarchically between levels and products themselves are isolated from the production model (Federal Ministry for Economic Affairs and Energy, 2018). The new model, with flexible systems and machines, functions distributed throughout a network that crosses company boundaries with participants interacting across hierarchical levels with open communication and products representing an integral part of the network thus represents a paradigm shift for companies and the economy at large.

2 POLICY AREA IMPACTS

The Fourth Industrial Revolution promises to have multiple and complex effects on economies and societies around the world. The drivers of the revolution are, in their essence, a product of technological development and the direct impacts are thus expected to be centred around productivity. Furthermore, due to the proliferation of robots and increase of automation in the economy, labour market ramifications are to be expected. Policymakers will likely encounter these two impacts first, however, there are several other less direct impacts that are worthy of study. Firstly, changes in the labour market and technological changes in general, especially if disruptive and abrupt, will eventually have to be reflected in the educational system and other education-related areas. Secondly, the increased automation and digitalisation of the economy will result in the increased urgency of digital security measures. Policymakers should be able to respond to vulnerabilities that are becoming ever more important and critical in an increasingly digitalised economy. Other implications of the Fourth Industrial Revolution include increasing income inequality, the increasing risk of entire geographical regions "falling behind" and the changing sectoral structure of the economy due to the emergence of "winner" and "loser" sectors (Collins et al., 2016).

To ensure that the Fourth Industrial Revolution results in the most optimal scenario and delivers benefits to all, policymakers will have to think and act in two main directions:

1. Enabling an environment which supports capturing the potential benefits by incentivising and encouraging adoption of modern technologies, including robotization and automation.
2. Creating new possibilities for redisposition of the portion of the workforce whose jobs were affected as productivity increases depend strongly on cooperation between systems and workers.

Policymakers will have a strong incentive to encourage and enable the rapid adoption of automation technologies across the economy to ensure productivity increases reach their full potential, especially since early adoption could benefit from incentives and other types of policy support. However, solutions will have to be developed to support the redeployment of potentially large numbers of displaced workers. This promises to be a societal challenge, not just an economic one. As governments are generally not adept at anticipating the types of jobs that could be created or new industries that might develop, initiating a broad dialogue about the future needs of the economy would be beneficial (Manyika et al., 2017).

2.1 Productivity

Productivity is the measure of production efficiency, commonly expressed as how much output is obtained from a given level of input (Syverson, 2011). It is an important measure of the strength of an economy and is considered a country's greatest tool to improve the standard of living over time through an increase of output per worker (Krugman, 1992).

There are three methods commonly used for measuring productivity: partial factor productivity, multifactor productivity and total factor productivity (Syverson, 2011), of which the latter is the most accurate. Considered as the true measure, it takes into account all factors of productivity and is the hardest to assess (Sargent & Rodriguez, 2000). Multifactor productivity, albeit a less holistic approach, is more commonly used as it encompasses a selected bundle of factors, but not all. In essence, it compares the evolution of output with the evolution of combined labour and capital inputs (Arnaud, Dupont, Koh & Shreyer, 2011).

The growth of productivity is closely linked to economic growth (OECD, 2001). According to the Solow-Swan model, long-run economic growth is composed of several different factors: capital accumulation, labour or population growth and increases in productivity, also referred to as technological progress. Out of all these factors, changes in technology are the only source of permanent increases in productivity. While workers may work more during periods of increased demand, their productivity, measured by the value of what a unit of labour produces per unit of time does not permanently increase without improvements in technology (Gorman, 2001). Furthermore, research suggests that economies which specialize in high-tech activities see higher productivity growth rates than others, leading low-tech countries to achieve lower prices on their goods, as long as there is no price control involved (Lucas, 1988; Grossman & Helpman, 1991).

An increase in productivity is the hallmark of every industrial revolution. However, counterintuitively, global labour productivity growth has slowed during the past decades despite an apparently relentless technological advancement (Remes et al., 2018). This has spurred a debate among scholars on whether developed economies suffer from a productivity slump. The reasoning for this seeming paradox has been speculated to be due to various factors, such as:

- Mismeasurement (Brynjolfsson & McAfee, 2012 & 2014),
- Persistently low interest rates (Liu, Mian & Sufi, 2019; Summers, 2015),
- Failure of companies to organise themselves to be more productive due to an increasing lack of competition (Wessel, 2018),
- Economic consequences of the 2007–08 global financial crisis, such as persistent weak demand and uncertainty (Remes et al., 2018),

– Transition costs and the cannibalization of incumbent revenues of digitization (Remes et al., 2018).

Autor, Mindell and Reynolds (2019) posit that the reason for the seeming lack of productivity growth lies in the questionable benefits of some new innovations. While new technologies offer a mix of job substitution and job complementarity, the mix differs greatly across technologies and industries, as do the productivity impacts, i.e. innovations that raise productivity do not necessarily displace workers at a similar rate and innovations that displace workers do not necessarily raise productivity at a similar rate. The authors posit that some digital innovations introduced in recent decades fall into this category.

Automation and the consequent proliferation of robots is one of the key elements of the Fourth Industrial Revolution and holds promise to improve productivity. Historically, the contribution of industrial robots to productivity has been notable despite a low density of robot applications: between 1997 and 2007, robots contributed 0.37 percentage points to annual labour productivity growth across 17 developed countries or about one tenth of aggregate economy-wide growth, raising total factor productivity and wages while lowering output prices (Graetz & Michaels, 2015). According to Manyika & Chui (2014), automation has the potential to raise productivity growth globally by 0.8 to 1.4 percentage points annually, provided that displaced workers would re-join the labour force and remain as productive. Furthermore, they calculate that by 2065, automation could potentially enhance productivity growth in the largest economies in the world (G19 plus Nigeria) of the equivalent of an additional 1.1 billion to 2.3 billion full-time workers.

Modern industrial robots are autonomous, flexible and versatile and their capabilities are profoundly changing manufacturing. Robotics technology is maturing and expanding, extending manufacturers' expectations of the technology's value beyond the traditional scope of reducing labour costs and improving labour productivity. Instead, robots are adding a new set of values to production processes, such as including producing higher-quality products with more innovative designs, shortening delivery cycles and introducing flexibility and customization. Examples of flexibility and customization made possible by robotics are the emergence of just-in-time assembly and Lot Size 1 production, respectively (PricewaterhouseCoopers, 2018a).

The automation of processes improves performance and consequently improves the efficiency and effectiveness of activities as it reduces errors, improves quality of end products and the speed at which they are created (Manyika & Chui, 2014). One such example is connecting industrial robots with Internet of Things technologies, allowing the collection of performance data, which provides insights that can improve production efficiency. Between 2015 and 2017, General Motors connected one quarter of its industrial robots to the internet, which has prevented assembly line interruption and saved on robot replacement and downtime, avoiding approximately 100 potential failures, which can take as long as eight hours each (Black, 2017). Stopped production, also known as downtime, has a very high cost in manufacturing, especially in the automotive industry, where the cost of a minute of downtime was about 22,000 US dollars on average in 2006, rising up to 50,000 US dollars per minute in some facilities (Advanced Technology Services, 2006). The cost savings of introducing Industry 4.0 elements in existing organisational structures can therefore be substantial.

Robots are being increasingly used in developing countries as well – China is already the world's leading buyer of robots, meaning the contribution of robots to worldwide growth will likely increase in the coming decades (Graetz & Michaels, 2015). Furthermore, due to the make-up of the workforce and the prevalence of routine jobs in developing countries in contrast to a higher share of jobs that require creative work in high-income economies, robotization could increase productivity by a higher degree than in developed countries but in turn create more problems for the labour market (Schlogl & Sumner, 2018).

Industrial robots are spreading beyond large enterprises to small and medium-sized enterprises (hereinafter: SMEs), largely as a result of declining prices of robots; from 1990 to 2005, the prices of industrial robots have halved and between 2005 and 2014, they dropped by another 30 percent to an average of 133,000 US dollars (Graetz & Michaels, 2015). The average price is predicted to fall by another 22 percent by 2025.[1] (Sirkin, Zinser & Rose, 2015). However, SMEs face other challenges in industrial robot adoption, including the lack of specialized workers to maintain and program industrial robots, as well as the availability of space and low-volume high-mix production with less mass production, making robot implementations more difficult (Williamson, 2019). Collaborative robots (hereinafter: cobots) represent a solution to this problem (Gualtieri, Palomba, Wehrle & Vidoni, 2020).

The rise and increased use of cobots is also expected to drive the robot market in the coming years (International Federation of Robotics, 2016). Cobots are generally divided into three segments: cobots with a payload capacity under 5 kilograms, between 5 and 10 kilograms and lastly over 10 kilograms (Jakupović, 2019). The main producers of this kind of robot include Universal Robots, KUKA, MABI, FANUC, Quanta Storage and Yaskawa. Overall, the collaborative robot market is expected to rise from 633 million euro in 2018 to 10.78 billion euro in 2025, a compound annual growth rate of around 50 percent (MarketsandMarkets in Jakupović, 2019). These expectations stem from a low initial investment of this type of robot and the high return rates on such investments, enabling their use in SMEs, which are also more likely to lack the necessary funding to invest in more expensive industrial robots and thus find them cost-prohibitive. These will predominantly drive growth in the mid-payload segment. Higher demand growth is also expected for

1 Not adjusting for inflation or improvements in quality.

collaborative robots intended for assembly and material handling, especially in the automotive and furniture industries (Jakupović, 2019).

Industrial robots demand is also growing rapidly. ABI Research (in Jakupović, 2019) have forecast that the industrial robot market size will reach 19.3 billon euro by 2027. Mobile robots are forecast to become a key demand driver in this segment. These may include autonomous guided vehicles and autonomous mobile robots. Mobile robots complement robotic arms in industrial plants, expanding automation possibilities in existing industrial robot implementations (Jakupović, 2019).

The overall market for Industry 4.0 products and services is predicted to grow by a factor of six between 2018 and 2023, from 41 billion euro to 271 billion euro with a compound annual growth rate of 37 percent, representing a market opportunity in addition to the productivity benefits of Industry 4.0 implementations. Two thirds of the Industry 4.0 market have been composed of six cornerstones: hardware, connection equipment, cloud platforms and analytics, applications, systems integration equipment and digital security products and solutions. The remaining third of revenues in the Industry 4.0 market have, on the other hand, stemmed from support technologies, such as additive production, 3D printing, augmented and virtual reality, cobots, machine vision, drones and autonomous vehicles (Jakupović, 2019).

The increasing robot density has the potential to be beneficial more widely in the economy and society, as robot adoption has the potential to promote economic growth in developed economies, especially economies with aging workforces (Acemoglu & Restrepo, 2017a). Robotics technologies are diminishing the economy's reliance on human labour at a time of a deepening talent shortfall and low unemployment of the post-crisis recovery period (PricewaterhouseCoopers, 2018a), as well as improve lacklustre productivity growth. Furthermore, as demographic trends take an increasing toll on the labour supply and thus put continued growth of developed countries in question, robotization and automation could counteract this stagnation and represent a new engine of economic growth (Manyika et al., 2017). On the other hand, Graetz and Michaels (2015) found that the marginal returns on increased robot densification seem to diminish fairly rapidly, although robot adoption is still quite low overall.

With the continued proliferation of robots and diminishing marginal returns, the attractiveness of operations automation could diminish gradually as it becomes increasingly less able to respond to evolving needs and its value proposition to businesses loses attractiveness (Jakupović, 2019). In order to continue providing suitable returns on investment, new forms of automation would have to be developed. These forms would be more wide-ranging than the automation implementations used today in existing facilities, where automation mostly strives to replace human tasks and integrate into existing human-centric processes (Autor, Mindell and Reynolds, 2019). These new forms would unlock new potentials and not just improve on existing task effectiveness. All stages of industrial production would require extensive remodelling, from planning, engineering, installation to operations. The Industry 4.0 smart factory model also requires a more holistic approach to automation and one that anticipates the future evolution of automation systems. Artificial intelligence applications could assist in the reorientation of engineering models from human-oriented to more machine-oriented to accommodate the increasing levels of automation and which could surpass the productivity levels of current human-led approaches (Jakupović, 2019). However, according to Autor, Mindell and Reynolds (2019), supply and demand, political relationships and innovation are dynamic forces, which affect even the most stable and uniform products, and production systems are under constant pressure to adapt to these changing conditions. Within current technological limitations, human presence will likely remain better than machinery at providing the sort of flexibility that can react to disrupting external events such as Brexit or a global virus pandemic for the foreseeable future.

Table 2 summarizes the main issues in the area of productivity and possible policy solutions.

Table 2: Subchapter summary: Potential impacts and policy responses related to productivity issues

Impact	Policy responses
Positive impact on economic growth, potential to counteract aging workforces, cut labour costs, however, varying productivity impacts by industry/region.	Governments need to ensure basic factors for productivity increases: – Facilitate trade – Encourage FDI and mobility of skilled labour – Knowledge sharing, especially between business and scientific/higher education institutions – Improve access to human and financial capital – Minimize inefficiencies in resource reallocation Policy responses which specifically target automation: – Framework improvements for robotization and automation while addressing societal concerns for privacy and security – Investment in next-generation digital infrastructure – Grants and loans to companies – Establishment of competence centres/centres of excellence, which can drive adoption among SMEs

(table continues)

(continued)

Impact	Policy responses
	– Leading by example – automation of public sector through increased use of robots and cobots Governments should help companies in affected industries restructure: – Providing grants and loans – Facilitating centres of excellences, either government or trade association-backed, which can spread awareness and provide consultation

Adapted from: Graetz & Michaels (2015), OECD (2015a), Schröder (2016), Sirkin, Zinser & Rose (2015), The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company (2017).

With increasing robotization and automation, labour costs are also impacted. According to Sirkin, Zinser & Rose (2015), robots have the potential to cut labour costs significantly, for example by as much as 33 percent in South Korea, 25 percent in Japan, 24 percent in Canada and 22 percent in the United States and Taiwan. However, the productivity increase observed thus far varies by industry. For example, according to Graetz and Michaels (2015), between 1997 and 2007 across 17 developed economies, a 0.02 increase in the number of robots per million hours worked led to a three percent increase in productivity in the construction industry, however, an equal 0.02 increase in the number of robots per million hours worked in the utilities industry led to a 43 percent increase in productivity. New technologies will also impact the cost structure of firms. According to PricewaterhouseCoopers (2016a), operational cost reductions due to implementation of Industry 4.0 initiatives in companies will differ between industries. While on average, companies will achieve 3.6 percent cost savings, forest, paper and packaging companies can achieve a 4.2 percent cost reduction, whereas transportation and logistics as well as companies in the metals industry can expect cost reductions of 3.2 percent. This differing cost and productivity impact will change the sectoral structure of the economy by producing winner and loser sectors. In Table 3, these sectors are identified according to Collins et al. (2016). The different productivity impacts of robotization on different industries present a challenge for policymakers.

Table 3: Summary of most impacted sectors by the Fourth Industrial Revolution

Positively impacted sectors	**Negatively impacted sectors**
– ICT and electronics – Automotive – Transportation and logistics – Healthcare	– Retail – Telecommunications and media – Finance (including insurance)

Source: Collins et al. (2016).

The Fourth Industrial Revolution is as relevant to manufacturing companies as it is to service companies, as it increases the rate of structural change in the services sector, as well as accelerates the blurring of the distinction between manufactured goods and services a phenomenon known as servitization (Frank, Mendes, Ayala & Ghezzi, 2019). Servitization refers to the transformational processes with which companies shift from product-centric to more service-centric business models and logic (Kowalkowski, Gebauer, Kamp & Parry, 2017). Within the context of Industry 4.0, servitization provides value not just to the customer, but also to the firm’s internal processes by providing a channel to gather data and information, thus reducing time to market and improving the product life cycle and value stream (Frank, Mendes, Ayala & Ghezzi, 2019).

Artificial intelligence, robotics and machine learning are all essential elements of the Fourth Industrial Revolution and their combination promises to create revolutionary applications not only in manufacturing and services, but in society at large as well. One such application are autonomous vehicles. A fundamental reshaping of mobility could have profound effects on human work and lives (Autor, Mindell and Reynolds, 2019). According to Jakupović (2019), around 30 different industries would be profoundly impacted by a major diffusion of autonomous vehicles, from the automotive industry to automotive repair, public transport, transportation and logistics, emergency medical services, insurance, construction, road management, urban planning, healthcare, ICT etc.

Furthermore, the convergence of ICT and automotive will accelerate in the future. By 2030, electronic components are projected to make up 50 percent of the cost of a car (Cornet et al., 2019). Traditional automobile manufacturers will likely face increased competition from technology companies, especially those that will focus on autonomous vehicles. Automotive repair services could face a loss of demand due to a drop in accident rates and less parts failure due to a smaller number of mechanical components and a reorientation of car engineering towards fleets as car ownership rates fall due to an increase usage of mobility as a service (MaaS) solutions, all unlocked by autonomous vehicle adoption (PricewaterhouseCoopers, 2019).

Autonomous vehicles would allow cheaper ride hailing services as well as effectively serve areas that are currently unserved or underserved by public transportation. They also stand to change consumer perceptions regarding different journey types, especially regarding journeys that are now avoided or unwanted by consumers, such as long-distance driving or driving in congested traffic (Jakupović, 2019).

Furthermore, autonomous vehicles could facilitate mobility of groups that are currently less mobile, be it due to disease, old age or disability. Autonomous mobility would allow the elderly to live independently in their own homes for longer, reducing demand for long-term care facilities, reduce the reliance of people with disabilities on public transportation, ameliorating living conditions for people with disabilities in rural areas and other areas with poor public transportation (Saripalli, 2017).

Autonomous mobility, the form of automation that is receiving a large amount of public attention, private investment and engineering development, has the potential to be a leading use-case for artificial intelligence and robotic systems. These systems hold promise for new applications and services, novel products and occupations that could positively impact productivity (Autor, Mindell and Reynolds, 2019).

Based on the information presented in this chapter, we find that the Fourth Industrial Revolution will increase overall productivity. The benefits of automation, robotization and other drivers of the Fourth Industrial Revolution will likely have differing effects across regions and industries, but their overall contribution to productivity will be positive.

The policy options that governments possess to facilitate the transition to the new paradigm are varied, but in order to devise the right policies, governments should understand which factors impact technology adoption and diffusion. The OECD (2015a) has identified the following: trade levels, foreign direct investments and mobility of skilled labour; the exchange of knowledge through interactions between businesses and scientific and higher education institutions; the extent of knowledge-based capital; and the availability of human and financial resources, among others. On the other hand, inefficient resource reallocation caused by a lack of competition, rigid labour markets, and barriers to growth restrict productivity increases. For example, the sensitivity of capital investment to a change in patent stock, a proxy for technological innovation in companies, is almost double in Norway, a country with efficient contract enforcement, relative to Italy, a country where contract enforcement is inefficient and costly (Andrews, Criscuolo & Menon, 2014). Governments should therefore address these factors and ensure they are not a hindrance to the economy.

Governments can also help by designing targeted framework improvements to deal with issues that specifically hinder robot adoption and automation. Ensuring the right conditions for autonomous vehicles or delivery drones, for example, requires adjustment of the road or airspace infrastructure rules, vehicle safety regulations, and infrastructure investments to name a few. However, it is imperative that societal concerns regarding privacy and safety are addressed (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017).

While framework improvements are necessary for the successful implementation of robotization and automatization, governments should also promote early technology adoption to ensure that productivity gains will be enjoyed by a larger share of the economy and to prevent company complacency. Examples of such policies include investments in next-generation digital infrastructure, increasing direct investment in automation through government grants and loans, be it directly to companies or to centres of excellence, as well as attracting foreign capital, talent and experts (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017). These types of investment may be especially useful in developing countries or in rural areas, where current infrastructure may be subpar. Some European countries, e.g. Romania, that had very poor communication infrastructure in the past, are now among the top European countries in terms of internet speed, as a result of such investments (Kelly, Liaplina, Tan & Winkler, 2017).

Furthermore, special care should be given to SMEs and their needs and abilities. There is a significant relationship between company size and implementation of robots. SMEs are less likely to be sufficiently prepared for Industry 4.0; they are poorly networked, lack awareness and subsequently also strategies regarding Industry 4.0 issues. Government or trade association-sponsored centres of excellence or competence centres could spread awareness and offer consultation services to SMEs (Schröder, 2016; The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017).

Finally, a way for governments to support and promote robotization and automatization is to lead by example. While the public sector is less automatable than other sectors of the economy, governments should introduce automated and robotised solutions in various public-sector settings (elderly care, healthcare, tax, etc.). In Denmark, for example, automatable tasks currently represent only 27 percent of total work hours in the public sector, compared to 40 percent in the economy as a whole (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017). While increasing innovation, providing know-how enhancement opportunities to the private sector and serving as a champion for Industry 4.0, such efforts also have the added benefit of improving public sector productivity (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017).

2.2 Labour market

The changes brought about by robotization and automation have the potential to substantially disrupt labour markets and have, to a certain extent, done so already. However, the amount of disruption that will occur as a result of these changes is unclear at this point. This is a topic that has been widely discussed in recent years. Still, several recent relevant studies have come to conflicting results.

Table 4 summarizes possible policy responses to ensure a positive impact on the labour market.

Table 4: Subchapter summary: Potential problems and policy responses in the labour market

<table>
<tr><th>Impact</th><th>Policy responses</th></tr>
<tr><td>Authors disagree on whether robotization and automation will impact job creation. However, it will cause shifts in the labour market.</td><td>Policymakers will be vital in ensuring that automation and robotization have a positive impact on the labour market. Policies need to target:

1. those entering the workforce, governments should facilitate cooperation between businesses and higher education institutions to establish specialized study programmes which:
a) should promote creativity, social skills, systems thinking and other hard-to-automate skills
b) focus on big data and analytics, augmented reality, additive manufacturing, the cloud technology, cybersecurity, industrial Internet of Things, horizontal and vertical system integration, autonomous robots.
2. those already working, reskilling opportunities must be available. Policymakers can:
a) encourage cooperation between educational institutions and the private sector in the creation of reskilling programmes
b) follow best practices already employed in different countries
c) support transitioning workers through wage subsidies and other financial support.</td></tr>
</table>

Adapted from: Acemoglu & Restrepo (2017b); Arntz, Gregory & Zierahn (2016); Autor (2015); Frey & Osborne (2013); Rüßmann et al. (2015); Sirkin, Zinser & Rose (2015); The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company (2017).

Acemoglu and Restrepo (2017b), Frey and Osborne (2013), as well as Sirkin, Zinser & Rose (2015) all state that automatization and robotization will result in job losses. Acemoglu and Restrepo (2017b) performed a study focused on the impacts of growth in robotization on the labour market equilibrium in the period between 1990 and 2007 and found that the implementation of one robot per thousand workers reduced the employment to population ratio by approximately 0.37 percentage points and lead to a 0.73 percent lower wage growth compared to an area with an absence of robots. In practical terms, this translates to one robot reducing employment by as much as 6.2 workers and one robot per thousand workers resulting in the reduction of the average yearly wages by 200 US dollars.

Providing a more detailed overview, Frey and Osborne (2013) researched and compared the likelihood and the extent of various professions being automated. They performed a study, the results of which are presented in Table 5 in the form of occupations that are most and least prone to automation. As seen in the left column under Most prone to Automation, there are several occupations that are almost certain (1 indicates a certain event, while 0 indicates an unlikely event) to be automated which means that these jobs will likely be lost. However, there are also occupations which will hardly be affected by the Fourth Industrial Revolution. Examples of such are gathered in the right column. According to Sirkin, Zinser & Rose (2015), only 10 percent of jobs that can be entirely automated have currently already been taken by robots. The authors argue that by 2025, machines will perform more than 23 percent of all jobs. Up to 50 percent of all of today’s work activities could be automated by 2055, though such an assessment depends on various factors and could perhaps be realized 20 years later (Manyika et al., 2017).

Table 5: Occupations, listed by most and least prone to automation

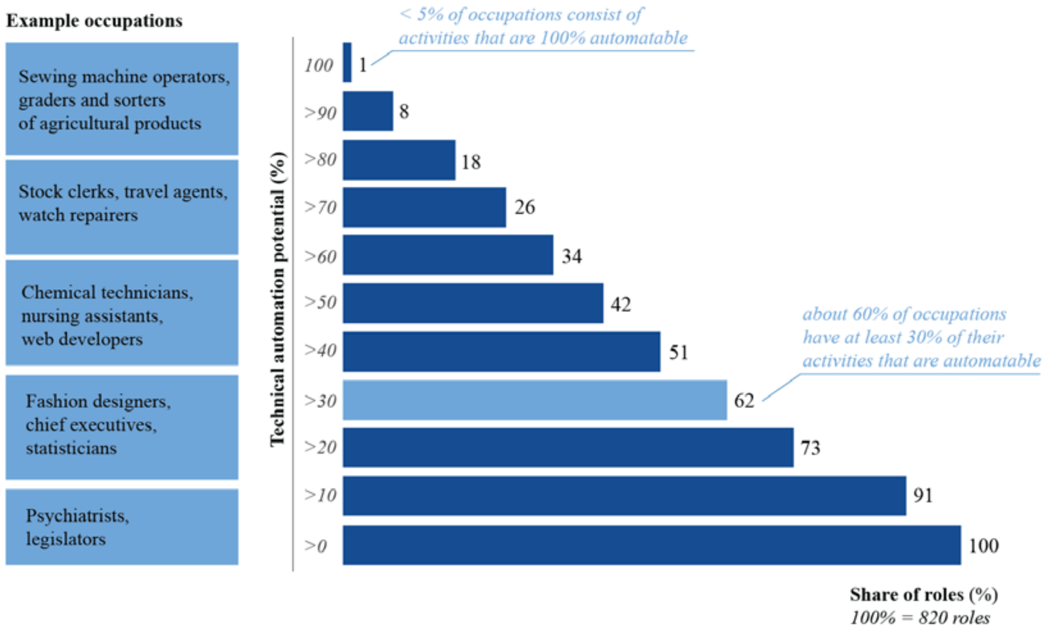
Jobs Most Prone to Automation ($P > 0.9$)	Jobs Least Prone to Automation ($P < 0.02$)
– Telemarketers – Tax preparers – Insurance appraisers, auto damage – Referees and other sports officials – Legal secretaries – Hosts and hostesses - restaurant, lounge, and coffee shop – Real estate brokers – Farm labour contractors – Administrative assistants, except legal, medical & executive – Couriers and messengers	– Mental health and substance abuse social workers – Choreographers – Physicians and surgeons – Psychologists – Human resource managers – Computer systems analysts – Anthropologists and archaeologists – Marine engineers and naval architects – Sales managers – Chief executives

Source: Frey & Osborne (2013).

Other authors are more sceptical about the possibility of complete job automation. Autor (2015) believes that most middle-skill jobs, assumed in some studies to be taken over by robots, will persist - or in some cases potentially even grow. He claims that the potential for automation is vastly overestimated. Autor (2015) argues that only certain tasks and not entire occupations are susceptible to automation, leading to a likely scenario in which machine and worker co-exist to the degree that they are complements, not substitutes. Examples of such professions include medical para-professions, e.g. radiology technicians, phlebotomists, and nurse technicians, as well as certain manual labour occupations including plumbers, builders, electricians, air-conditioning installers, and automotive technicians. He argues that we should look at the technological change as replacing certain tasks rather than occupations and use it as an advantage, not view it as a threat. A similar argument is put forth by Arntz, Gregory & Zierahn (2016), who posit that assuming a complete automation of jobs, as opposed to job-tasks, leads to an overestimation of job automatability. Mihelj (in EU Robotics, 2016) concurs, believing that automation and robotics represent a connection between the cyber and the physical world and do not serve as a replacement for workers, but merely as an advantageous upgrade of their existing abilities. The first step towards this, however, is establishing physical and cognitive interaction. In a study of the impacts of Industry 4.0 on German manufacturing carried out by Rüßmann et al. (2015), a positive trend of growth in employment has been found, which led them to predict a six percent increase in employment stimulated by Industry 4.0 through 2025. A study performed by PricewaterhouseCoopers (2018b) showed that while the management of many larger corporations is in favour of automatization, still more than 50 percent of those believe that it should be a complementary activity and are exploring possibilities and related benefits of workers and robots working together towards a common goal. Additionally, 39 percent of executives are actively evaluating the impact of AI their businesses and even more so on their future workforce skill needs. Graetz and Michaels (2015) found that there is no significant relationship between the increased use of industrial robots and overall employment. Lastly, Domadenik, Drnovšek, Lah and Smolar (2017) found that there are visible differences between the impact of automation on employment based on whether it substitutes or augments jobs. The listed authors largely agree on one thing: automating entire jobs is not likely, but at least a small part of most every job is automatable.

When jobs are dissected into individual tasks performed by an employee, most jobs are comprised of several smaller activities. For example, a car salesman typically prepares the vehicles, interacts, and negotiates with potential customers, arranges test drives, and ultimately creates invoices and deals with financing. All these tasks are different and for this reason require different capabilities and knowledge. Some of the repetitive tasks (e.g., invoicing) are more likely to be automated than tasks that require a deeper understanding of human emotions (e.g., price negotiation). As shown in Figure 3, approximately 60 percent of all occupations have the potential of automation in at least 30 percent of their activities, while less than 5 percent of occupations consist of activities that are 100 percent automatable (Manyika et al., 2017).

Figure 3: Automation potential based on demonstrated technology of occupation titles in the United States (cumulative)



Source: Manyika et al. (2017).

Even though most research emphasis is put on the technological side of automation feasibility, automatability is not as one sided and depends on several intangible factors as well. It can be determined through different criteria, some among which are the technological, economic, legal, political, and sociocultural requirements to automate the task. These criteria take into consideration the complexity and reproducibility of the task, financial risks given capital and labour cost, the corresponding regulations, unionization of the workforce and social expectations (Schlogl & Sumner, 2018).

The likelihood of automation varies across sectors. Automation in predominantly physical labour-intensive sectors, e.g., manufacturing is far more likely than in sectors which focus on people, such as health or education. The main reason behind it lies in predictability of the job tasks, which is essential to automation. The more routinized a task is, the easier it is to create a representative workflow model to follow and predict the activities of a given profession and the simpler and more likely the automation is (Gibbs, 2017). Jobs that consist of human interaction, creativity and critical thinking are harder to predict and automate (Vozza, 2017).

This leads to a variation in job automatability among countries, too. Countries with a predominant focus in the service sector have a lesser potential to be automated than those with focus on agriculture or manufacturing. This corresponds to the poorer countries having more jobs at risk of a complete automation, as routinized work generally prevails in low-income economies.

On the other hand, agriculture as a whole is likely to see a higher level of automation in wealthier countries with larger budget for technological innovation than in developing countries as there is a noticeable positive relationship between automatability and income level of a country or area. This holds true because it is financially more feasible to invest towards automation of processes in countries or areas with expensive labour force than it is in countries or areas where the local labour force is cheap (Schlogl & Sumner, 2018). Lastly, researchers found that automation potential is also centred around densely populated metropolitan cities in highly developed countries. According to this study, the three leading countries in terms of automatability potential are Japan, India, and China, respectively (Manyika et al, 2017). However, rather than precipitating a high volume of unemployment, automatization and robotization, it is more likely to result in stationary wages and deindustrialization (Schlogl & Sumner, 2018).

One thing appears to hold true; just as certain cognitive intensive tasks and jobs seem impossible to be automated or performed by robots today (e.g. psychotherapy), in the past there was a similar perception of tasks like driving, which we now know are automatable and are rapidly evolving and already becoming a part of our lives.

Unlike the dilemma on how many jobs will be destroyed by the Fourth Industrial Revolution, most all researchers agree on one fact. Technology has always been destroying jobs and it has always been creating jobs (Brynjolfsson & McAfee, 2012). According to the World Economic Forum (2016), more than 60 percent of students in the primary and secondary stage of education may eventually work in jobs that do not exist today. Whereas this does sound like an exaggeration at first, it holds true, that many jobs which exist today (e.g., AI engineer, data scientist, etc.) did not exist a decade ago. This type of swiftly evolving economy makes predicting and anticipating the needs of the future labour force a tough, yet a very important job.

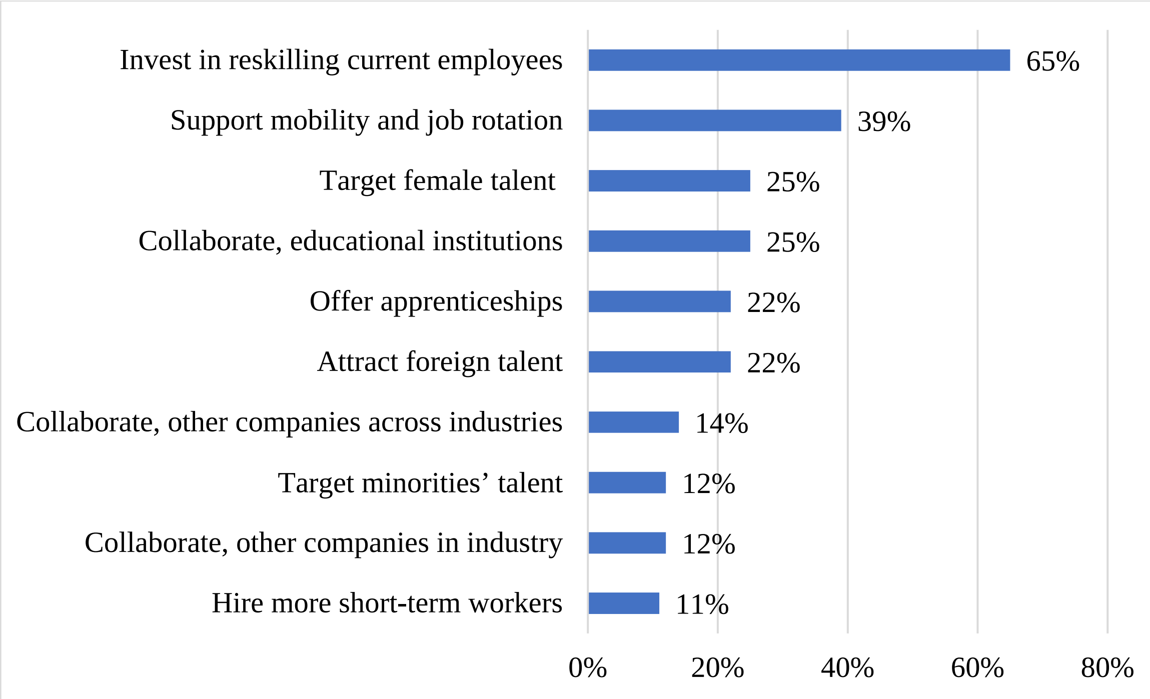
Based on the information presented in this chapter, we find that the Fourth Industrial Revolution will have divergent effects on job demand. Despite the divergence in opinion and evidence regarding this topic, while most all jobs contain tasks that are automatable, some jobs are more automatable than others, leading to diverging demand for jobs. Some jobs may be made obsolete in the coming years, while many will change as some tasks are automated away. Finally, many new previously inexistent job profiles will be created.

This set of conflicting impact assessments does not provide a clear path to policy solutions. Instead, it demands a certain level of flexibility from policymakers. However, one should not underestimate the power of policy when dealing with labour market disruption. In a study of the impact of automation in Denmark, The Tuborg Research Centre for Globalisation and Firms, and McKinsey & Company (2017) emphasized that it is the policymakers who will be vital in ensuring that automation leads a positive impact on the labour market by increasing and promoting both skill development and job mobility to ensure a smooth workforce transition. To achieve that, policies need to target those entering the workforce and those who are already working. In order to successfully target the former, governments should facilitate cooperation between businesses and higher education institutions that should lead to the establishment of specialized study programmes. These programmes must present an improvement over the existing programmes, with the main adjustments being done to the curricula, education design and teaching methods. They should promote creativity, social skills, systems thinking and other hard-to-automate tasks (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017; Manyika et al., 2017). Competitiveness of human labour vis-à-vis robots and automation can also be improved through a labour tax reduction.

In addition to workers, employers will have to adjust to new labour market conditions, too. To successfully tackle the increase in demand in new professions, manufacturers and organizations should formulate a strategic workforce plan that will enable them to assess the required number of employees with newly developed skills and competencies. By doing so, they will be able to intervene early enough to include their existing employees in these training and development programmes and prepare them for adopting new roles (Rüßmann et al., 2015).

According to data presented in Figure 4, companies are indeed following the proposals outlined and planning on pursuing various innovative workforce strategies, such as investing in reskilling and supporting mobility and job rotation, as well as increasing efforts to attract female talent and collaborate with educational institutions more closely than in the past.

Figure 4: Future workforce strategies, share of respondents pursuing strategy



Source: World Economic Forum (2016).

The World Economic Forum (2016) has developed a proposal for an action plan for the adjustment of companies and governments to the challenges posed by the Fourth Industrial Revolution that includes several recommendations. The first is to restructure human resource management practices. The changing of skills, roles and entire job positions should be reflected in a new, more strategic, flexible, analytic, and agile role of human resource management. Human resources should be actively included in strategic planning with talent management, training, and skill-building at the core of their activities. Modern technologies including virtual and augmented reality should be embraced in training and reskilling, whereas the recruiting process has the potential to benefit the most by utilization of artificial intelligence, saving valuable time by sourcing and screening potential candidates, and removing bias human bias in candidate evaluation. The larger the available data and information pool, the greater the evaluation accuracy gap between a human and AI. With repetitive administrative tasks aside, the human resources manager can better focus on final decision-making (Ernst & Young, 2018).

The second recommendation is to utilize big data and analytics (World Economic Forum, 2016). Workforce planning as well as talent acquisition, retention and management can largely benefit from immense amounts of data, assuming that the data is analysed, presented and readily available for intelligent decision-making. Recognizing patterns in employee behaviour and performance enables informed forecasting, which in turn allows for better talent management, and ultimately, a potential boost in productivity. The results of such data analysis should be reflected in short- and long-term strategies.

Furthermore, companies should embrace a diverse workforce. Talent diversity has been proven to drive innovation and creativity, two of the most distinctive skills in the race against robotics. Background diversity, be it in the domain of gender, age, ethnicity, or sexual orientation introduces a global and cultural awareness and gives employees a solid ground for the development and improvement of soft skills (PricewaterhouseCoopers, 2018b). Reduction of unconscious bias by digitalizing and introducing modern technology to human resource operations applies to the diversity aspect as well.

The fourth recommendation is the adoption of remote work and flexible working hours (World Economic Forum, 2016). The trend of companies embracing remote and flexible workforce has now moved beyond just ICT companies. Work is becoming more about what employees do and their outcomes and less about when or where they do it. In a sense, it is a win-win situation for both parties. The possibility to work remotely enables comfortable workplace terms, gives workers more freedom and improves their work-life balance by not reducing the unnecessary work-related activities, such as the daily commute, to a minimum. Better work terms lead to higher employee satisfaction and, in turn, increase employee loyalty. Not being bound by the physical offices gives businesses an ability to recruit new talent without any geographical limitation. Flexible work goes hand in hand with alternative employment contracts and employer-worker relationships. Examples of such include digital freelancers and on-demand platform workers.

Finally, policymakers should reinvent education. As the result of ever-changing societal and economic shifts at a pace to which traditional education institutions cannot follow, education systems are increasingly becoming unfit for creating so-called jobs of the future. Some of the well-established jobs today did not exist a decade ago, and this trend is only expected to increase. Education curriculum needs to be changed in order to reflect the changes in the labour market. This can only be achieved through tighter cooperation between businesses, education institutions and the government (Manyika et al., 2017).

2.3 Education

Education is fundamental to the development and growth of an individual and is one of the main driving forces behind successful and sustainable economies. It is one of the most important tools an economy can employ to potentially reduce the income inequality. This is done through giving the poor the possibility to rise from poverty and by getting rid of existing differences between genders and social classes. The world’s leading countries have made considerable investments in the human capital to secure the future development and international competitiveness (Ozturk, 2001). The correlation between literacy and gross domestic product (hereinafter: GDP) per capita further supports these statements; some of the countries with complete or close to 100 percent literacy rate include Finland, Luxemburg and Norway, countries that also have some of the most successful economies in the world and among highest living standards. On the bottom side of the literacy rate list, we find mainly third-world countries including Guinea, Niger, South Sudan, Somalia, Chad and Ethiopia (Roser & Ortiz-Ospina, 2018; UNESCO, 2019). People in these countries face some problems that are no longer found in developed countries. The literacy rate in Niger is the lowest of all countries in the world at 28.7 percent. Coincidentally, two thirds of the Nigerien population live below the poverty line and suffer from the highest infant mortality rate (approximately 25 percent of children die before reaching age of 4) and one of the highest maternal mortality rates in the world.

However, education not only positively contributes to growth of economic and technological aspects of a society, but can be, in fact, much farther reaching. Education brings forth an ability to challenge the existing mentalities by asking critical questions, such as what is right and what is wrong, and when combined with basic knowledge and awareness on law enforcement, responsibilities and consequences, it can potentially reduce the amount of illegal activities and contain the violence in an environment. Doing so, it sets a solid ground for a society that is safe, responsible and more aware.

As discussed in the previous chapter about labour market disruption, many professions will be vastly affected by the fourth wave of technological advancement and might even render some of the professions completely obsolete. Others, however, have the potential to thrive and increase in demand. Moreover, some of the most important jobs of the future might not even exist today.

In order to fully reap the benefits and advantages of the coming Fourth Industrial Revolution and mitigate the potential negative effects it could have on the labour market and the society at large; fundamental changes need to be made to the official and unofficial education systems. The main objective should be to ensure that the workforce supply will match the future demand and, when that time comes, adequately skilled professionals will be prepared to tackle the new challenges (Lorenz et al., 2015).

The existing gap between the educational profile of youth and the skills required by employers will continue to widen, negatively impacting the desirability of these profiles. According to Mourshed, Farrell & Barton (2013), employers reported that new hires were sufficiently prepared for the job only in the following three sectors: education, financial intermediation and healthcare.

As the demand for skills relating to science, technology, engineering and mathematics (hereinafter: STEM) continues to grow, the shortage of graduates will increase further. This will require a reassessment of education systems and a shift of priorities within these systems

(Mourshed, Farrell & Barton, 2013). Just as the continued shift from agriculture to industry made high school education standard at the beginning of the 20th century, the shift towards robotization and automation could similarly require a new educational standard for the 21st century (Goldin & Katz, 2008).

Table 6 summarizes the main issues in the area of education and possible policy solutions.

Table 6: Subchapter summary: Potential issues and the corresponding policy responses in the field of education

Impact	Policy responses
Skills mismatch will only continue to widen. There is uncertainty about which skills students of today will need in the workplace of tomorrow.	Policymakers can reduce the skills mismatch and create a future-proof education by: – facilitating collaboration between private sectors and educational institutions in order to adapt programs and curricula – adjusting the higher education programs to follow technological trends and focus on hard-to-automate skills – promoting science, technology, engineering and mathematics (hereinafter: STEM) among prospective students – teaching life-long learning as a value and a skill – promoting employer investment in training and skills outside of specialized needs of each company

Adapted from: Crockett (2017), Gehrke et al. (2015), Lorenz et al. (2015), Mourshed, Farrell & Barton (2013), World Economic Forum (2016).

2.3.1 Skills mismatch

One of the biggest threats to arise is skills mismatch. We are already witnessing both continuously decreasing demand in certain professions, for example file clerks and machine operators, and a rapidly growing demand in others, e.g. web developers and AR engineers (Sakamoto & Sung, 2018). In Germany, for example, the shortage of university graduates in the fields of engineering, robotics and other IT-related programs due to additional demand, as a consequence of Industry 4.0, is expected to rise to 120,000 individuals by 2025 (Lorenz et al., 2015).

Skills mismatch is oftentimes a by-product of a sudden technological advancement combined with society's inability to conform and adapt to these changes. The curricula offered by most of education institutions are to a large extent still largely the same as they were decades ago, even though many aspects of society have changed drastically (McCauley & Swabey, 2018). As long as major shifts in the field of technology and work will not be reflected with proportional, relevant and timely changes in the way workers are educated and trained for the workforce, the skill mismatch will only continue to widen and the longer it will take for education systems to adjust, the larger and more difficult to overcome the gap will become.

According to the European Centre for the Development of Vocational Training (hereinafter: Cedefop), the term "skills mismatch" is oftentimes too narrowly defined. It is mainly used when referring to the phenomenon that describes employer's inability to fill job positions despite offering competitive salaries in an environment with overall above average unemployment rate. In practice, this means that young people and other jobseekers are unable to find jobs while at the same time employers are unable to find adequately skilled applicants. The reality is, however, that skill mismatch not only affects individuals looking for a job, but a large portion of the workforce. A survey by Cedefop across the 28 European Union member states in 2014 showed that in the European Union, approximately 25 percent of all surveyed educated individuals are overqualified for their current working position (Cedefop, 2018a).

This means that there are two different types of skills mismatch, which are divided and measured into two separate levels:

1. individual level,
2. firm level.

The first category relates to the degree to which existing employees have skills (or education level, or both) that are either above or below the level required and expected for the job position by the employer. The second category relates to the degree to which job applicants meet the skills desired by the hiring company. This means that the former category deals with skills mismatch of the workers with jobs and the latter deals with the job-seeking labour force (OECD, 2017).

Labour market inefficiencies, e.g., overskilling or overeducation, are likely to appear when highly qualified young professionals are faced with insufficient labour demand in their respective field of expertise, meaning that they are forced to accept jobs that are below their qualification level.

Of the two, overskilling is a better measure of skill mismatch for two reasons (McGuinness, Pouliakas & Redmond, 2017):

1. It incorporates all the skills an individual gathered throughout their career, regardless of whether they acquired them at an education or a work environment.
2. The required skills on the job position profile reflect the actual job tasks better than the required education level.

In order to successfully close the IT skills gap, education systems should work towards creating and implementing cross-functionally integrated programmes with an increased number of interdisciplinary study fields, with the main focus on integration of IT, engineering, business informatics and other underrepresented fields (Lorenz et al., 2015).

2.3.2 Soft skills

While the complete robotization and automatization of jobs might seem improbable at first glance, the startling reality shows that using only the technology that is already developed and commercially available today, as much as 45 percent of all job tasks that workers are paid to do have the potential to be completely automated and replaced by their robot-counterparts. Moreover, approximately 60 percent of all existing employees could experience more than 30 percent of their work automated (Manyika et al., 2017).

It may at seem counterintuitive at first, but the key advantage that workers have and which in some respects gives them the upper hand against the robots is the fact that they are more human (Vozza, 2017). This is true because unlike hard skills, which can be replicated by robots using machine learning, AI and automation tools; soft skills cannot be copied as easily. A human worker will never be able to keep up with machines in certain aspects, such as the capabilities of processing large amounts of data, lifting extremely heavy objects, capturing different spectra of light or precision and repeatability in general. Soft skills are the skills that give human labour the advantage against robots and capitalizing on these is of crucial importance in the era of the Fourth Industrial Revolution (World Economic Forum, 2016). This in turn means, education systems, business and society as a whole should put more importance on emotional quotient (EQ), as opposed to being predominantly IQ focused (Lund & Chui, 2018).

Andrews and Higson (2008) found that employers deem soft skills among the most important characteristics when considering a candidate. According to Davidson (2016), executives struggle with finding applicants who can communicate clearly, work effectively in teams and take initiative when it is needed. To separate individuals with lack of sufficiently developed social traits from their adequately prepared counterparts, companies are investing increasing amounts of time and money towards specific tests that measure these characteristics. Larger companies and corporations who hire more frequently and in larger quantities, take these tests a step further by hiring consultants, psychologists and human resource experts who specialize in testing these skills using different screening methods.

Allen Investments, an investment firm from the United States, hired a psychologist in 2014 to help them examine and determine skills and characteristics of their best performing existing employees and later used this information as a benchmark to develop a test and compare their personality traits with those of the applicants on their open positions. Some of the important characteristics they were looking for were organization abilities, leadership skills, ability to think critically, creativity, flexibility and adaptability, however the number one characteristic was the ability to communicate clearly, closely followed by teamwork capacity (Davidson, 2016).

The Fourth Industrial Revolution is likely to bring forth new jobs that put more emphasis on cognitive abilities as opposed to traditional jobs where physical skills are key - and this should be reflected in new, adjusted curricula of the official education systems. Universities should put more attention towards promoting personal characteristics that demonstrate a high level of emotional intelligence. Examples of such skills include creativity, problem solving, people skills, critical thinking, leadership and management, collaboration and teamwork, openness to personal development and innovation (Crockett, 2017).

Another crucial skill is adaptability. As previously mentioned, some important future jobs may not even exist yet, meaning that regardless of the effort and research, it is impossible to perfectly assess which activities these jobs will consist of, meaning that workers cannot be adequately educated and prepared for the role either. Adaptability is an important characteristic for both the employer and the employee, though most of the burden is likely to fall on the latter. Workers will simply need to be ready to accept change, learn the additional necessary skills or even go through a complete retraining programme in order to transition to another job position seamlessly (PricewaterhouseCoopers, 2018). In practice, this means that in the age of automation and robotization, advanced computer literacy and new skills related to machine operating will increase in demand so far as to become the norm, as comprehensive engagement with gadgets, IT systems and machines will become a part of workers' daily activities.

To successfully support the transition to a new industrial revolution, a cooperation between education systems and businesses needs to be established in a way that the solutions should encompass both individuals entering the workforce, as well as those already working. To reach the former, governments should facilitate a tighter cooperation between businesses and higher education institutions with the main goal to establish specialized study programmes tailored to the needs of the new market requirements. These programmes must present an improvement over the existing programmes, with the main adjustments being done to the curricula, education design and teaching methods. On the other hand, to successfully transition workers from obsolete positions, reskilling opportunities must be available through programmes created through a tighter cooperation between educational institutions and the private sector – especially SMEs. Governments should play a role of ensuring the necessary regulatory framework, as well as facilitating the creation of reskilling initiatives and programmes (World Economic Forum, 2016)

An example of good practice in the field of retraining is SkillsFuture, a Singaporean government-funded platform that collaborates with universities in providing reskilling courses to workers switching careers due to skills mismatch and low labour demand. In 2016 alone, 380,000 Singaporeans benefited from the retraining, an increase of 30,000 over the previous year (Hui, 2017). A similar example from Slovenia is a start-up called Smart Ninja, which offers a variety of coding courses to applicants with little-to-no prior experience in programming, and within months brings them to a level of proficiency that allows them to take on entry level jobs in web development and programming (Smart Ninja, n.d.). It is also important to emphasize that the transition of workers between different jobs should be continuously supported by both labour unions as well as online job platforms and job centres. Lastly, workers in job transition should be eligible to receive wage subsidies during the switching period (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017).

To support these activities, changes need to be facilitated the education system. New curricula should promote hard-to-automate skills and relevant future-proof skills (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017). Key areas of competency development should be based on the direction in which the market is moving. By adjusting the supply to the current and anticipated demand, we arrive at the following technologies that should be focused on: big data and analytics, augmented reality, additive manufacturing, the cloud, cybersecurity, industrial IoT, horizontal and vertical system integration, simulation and the field of autonomous robots (Rüßmann et al., 2015).

According to Netzer (in Deloitte, 2018), governments should reform apprenticeships and university programs and do considerably more to create and maintain a relevant IT culture. Writing computer software and creating mobile apps, for example, should become a regular part of anyone’s curriculum.

One of the recent events that drastically affected a large majority of the world in most every aspect of their life, but also globally disrupted education, was the coronavirus disease 2019 (hereinafter: COVID-19) pandemic. 1.3 billion learners, or approximately 73.8 percent of all enrolled scholars saw a drastic change to their daily routines, as 184 countries saw temporary closures (UNESCO, 2020). The closure of education institutions did not result in a complete shutdown, though. Most of the developed countries, especially those with proven tradition in technology adoption in education, have successfully digitalized their classes in a matter of days (Li & Lalani, 2020). Learning became e-learning and online platforms and virtual conferencing apps such as Zoom, Skype, Google Meet or Microsoft Teams saw record usage and completely replaced their physical real-world counterparts. Other relevant technological solutions, such as cloud service solutions and internet service providers played their part as well, in some cases offering their services at a significantly discounted rate or even at no cost. Whereas online learning can in some ways be even more effective than traditional learning, the unplanned pandemic consequently also shed a light on the micro and macro income inequality. Even in the most developed countries, not every scholar has sufficient knowledge or access to a computer, which proves as a problem in case of larger families as well. This is even more apparent in developing countries. According to Schleicher (2020), about a third of schoolwork in Indonesia requires access to a computer compared to 90-95 percent of schoolwork in some of the European leading countries, including Norway and Switzerland. In hindsight, a lesson to be learned is that students should be introduced to and encouraged to interact with digital technology at a younger age and be enabled access to the basic equipment as well as their homes be provided with functional internet connectivity.

Based on the information presented in this chapter, we find that educational systems will be affected by the Fourth Industrial Revolution. The effects of the Fourth Industrial Revolution on labour demand and the subsequent changes in the labour market will provide a strong impetus to adapt educational systems to new needs as well as enable worker reskilling to prevent negative economic and societal consequences.

2.4 Digital security

As already mentioned in the preceding chapters, technological change does not come in absence of potential risks and drawbacks. While the modern interconnectivity of digital supply networks, customers, smart factories and operations indeed enables new possibilities in value creation, there is also another side to it - the potential risks posed by cyber threats become greater and farther reaching. This presents a need for a fundamental change in how security is viewed in the era of the Fourth Industrial Revolution, specifically with regards to robots (Waslo, Lewis, Hajj & Carton, 2017). According to PricewaterhouseCoopers (2016b), the number one economic crime anticipated in 2018 is cybercrime. Increased use and larger share of interconnected smart devices, commonly referred to as Internet of Things, demands a wider open IT structure. This brings forth potentially bigger threat of security breaches in the form of cyberattacks that are much farther reaching (Symantec, 2017). Enabling the required transparency of data flow to support such operations on one hand while maintaining the highest level of security to prevent data leakage and hacks on the other is a demanding task and the margin for error is eminently small – while organizations need to protect themselves on all possible fronts, hackers need only identify the weakest point. Hence, a strategic assessment of cyber risks and development of integrated preventative solutions to mitigate the risk, commonly referred to as cybersecurity, is of crucial importance (Waslo, Lewis, Hajj & Carton, 2017).

There are several different ways attackers are able to gain access or, in some cases, complete control over the compromised device.

One of the most common types of virtual exploitation is called phishing. Using various techniques, some of which include falsifying email addresses or creating nearly identical copies of website landing pages as well as other types of unlawful electronic communication, hackers attempt to represent an otherwise trustworthy entity with the sole intention of stealing passwords, credit card details and other private information (Das, Kim, Tingle & Nipper-Eng, 2019). The attacks are particularly successful when the recipient lacks cautiousness, as the phishing email addresses and fraudulent website URLs often differ from the original in merely a letter or a symbol, e.g. @paypall.com as opposed to @paypal.com. Frequently, hackers request passwords from the victims under the pretence of assistance, routine maintenance, or security upgrades. The message may seem trustworthy as it appears to originate from an enterprise executive, bank representative and similar. Another way, through which users are baited onto fake websites is by opening the ads at the top of the search engine instead of using the first organic result (Imperva, n.d.).

Attackers may also make effort to install malicious software known as malware on the targeted devices which ultimately gives them the control and ability to monitor the system as well as receive back the information entered by the user (European Parliament, 2017). Certain sophisticated types of malware even possess the ability of autonomous spreading across the network. It is important to emphasize that victims of such attacks predominantly have to allow the malware in to the system themselves, which is why oftentimes phishing and malware go hand in hand, as the seemingly innocent document attached to the email may include a hidden malware installer (Rapid7, n.d.).

Lastly, the core of many attacks lies in social engineering. It is a technique used to manipulate and influence people by exploiting their personal characteristics, which may include but is not limited to: trust, helpfulness, curiosity, foolishness and fear, in order to get them to leak confidential information (European Parliament, 2017). One of the main advantages of social engineering is that “hacking human emotions” is easier than finding loopholes in a sophisticated IT ecosystem.

Perhaps the main difference between the former and future cyber threats is in the scale of the potential impact. The fact that product interconnectivity may nowadays extend all the way back to the supplier means that consequently cyber risk persists even after the product has been sold to the end-consumer (Sniderman, Gorman & Holdowsky, 2016). Additionally, we are currently witnessing a notable transition from traditional cyberattacks that merely exist within the digital sphere to those with actual physical world impacts (Waslo, Lewis, Hajj & Carton, 2017). This expands the cyber risk to new, critical aspects such as health and safety at work. This was the case with the infamous malware Stuxnet, a computer worm allegedly created as a result of a cooperation between Israel and the United States, which infected uranium enrichment centrifuges in Natanz, an Iranian nuclear facility. Stuxnet gained access to the Natanz network by unknowingly being physically brought to the facilities by an employee on a flash drive. The malicious code sabotaged the centrifuges by overspinning them meanwhile reporting falsified data of regular activity to the control room (Lauder, 2016). Considering an attack of such scale and complexity was successfully carried out in 2010, the rapid pace of technological advancement only further increases the importance of cybersecurity.

A study of cyber risk in advanced manufacturing performed by Deloitte and MAPI (2016) found that approximately 50 percent of interviewed executives lack assurance that their critical assets are adequately protected from external cyber threats. Likewise, 76 percent of manufacturers worry about data vulnerability (Accenture, 2016). Having said that, the reality is that as much as 31 percent of all surveyed companies in the technological sector has never conducted a cyber-risk assessment (Deloitte & MAPI, 2016).

In addition, oftentimes the key digital vulnerability lies within the organization itself, as four of the top ten cyber-threats involve employees, making human capital the weakest chain in the cybersecurity and thus the one most likely to be targeted (Deloitte & MAPI, 2016). The lack of sufficient employee awareness frequently results in security breaches that emerge from the inside.

Table 7 summarizes the main issues in the area of digital security and possible solutions.

Table 7: Subchapter summary: Potential issues and the corresponding policy responses in the field of digital security

Impact	Policy responses
Today's interconnectedness presents a risk for the economy. As the use of internet in smart factories and IoT, as well as the general level of digitalisation of the economy will only grow in the coming years, issues such as security breaches, data theft, system failure, loss of privacy could become more pressing.	Policy measures in order to address digital vulnerabilities are: – Industry 4.0 bill of rights – Strengthening monitoring – Kill switches in robots – Prevention through employee training

Adapted from: Deloitte & MAPI (2016), INCIBE (2015), Waslo, Lewis, Hajj & Carton (2017).

It is therefore imperative to thoroughly assess the cyber risk from various external and internal impact zones and take precautionary measurements. One of the key steps towards a secure and reliable digital environment is strategically planned delegation and clarification of tasks and responsibilities of each individual involved in the process. The reality is that a large majority of SMEs often do not have the required equipment nor the funds to improve their cybersecurity (INCIBE, 2015). It is also crucial to highlight that while an in-house IT cybersecurity team is highly beneficial, their findings, strategy and measures should be strongly integrated into the daily routine of both lower-end workers as well as the senior management and executives. Moreover, advanced protection from external threats such as IP protection and firewalls must be installed and constantly monitored.

However, even the seemingly most secure ecosystems tend to have loopholes and flaws that are often overlooked. In many instances, hackers spend anywhere from months to perhaps several years finding these opportunities and planning the attack that can come in various types and scales, varying anywhere from information theft to distributed denials of service. The latter describes an attack in which cyber criminals flood the network with a huge increase in website traffic that overwhelms the network and temporarily disables the availability of the network (Rapid7, n.d.). Sophisticated attacks can even happen simultaneously in several different places.

Aside from the precautionary measures to prevent the emergence of cyberattacks, organizations need also adequately prepare the defensive actions when these types of hostile contacts do appear. An effective way of testing company's resilience against cyberattacks that gained popularity in the last few years is by running the so-called Breach & Attack Simulations, offered by companies such as Cymulate and SafeBreach. By mimicking hostile contact throughout all stages of the attack, these simulations allow organizations to measure and assess their preparedness of handling cyberattacks effectively by exposing them to the real-world scenarios from both attacker's and victim's perspective (Cymulate, n.d.).

Innovations such as autonomous vehicles present another set of risks as their mobility and movement in the urban environment would mean that a malicious attack might put their passengers and bystanders at risk. Hacker attacks on the information systems powering autonomous vehicles have been detected in the United States even at this early stage of development (Suhadolnik, 2019). Technology and automotive-industry companies that are involved in the development of autonomous vehicles will thus have to place more emphasis on how to protect such complex and vulnerable systems while keeping them functional.

With regards to digital security issues presented by the increased robotization of the economy and society in general, responses that policymakers might consider include a kill switch in robots, the strengthening of monitoring and an Industry 4.0 bill of rights (European Parliament, 2015; Lin, Abney & Bekey, 2011). Countries are starting to take action – the European Union's Network and Information Security Directive is the first union-wide act on cybersecurity as part of its Digital Single Market initiative and will mandate security incident response teams across member states, among other solutions (European Commission, 2016).

Based on the information presented in this chapter, we thus find that the Fourth Industrial Revolution will increase the importance of digital security.

2.5 Other policy areas

In addition to the four main issues already addressed, other issues and trends presented by Industry 4.0 might require government action. We present them in Table 8. The changing structure of the economy, driven by phenomena such as servitization, the shift from product-centric consumption to services, could significantly change several industries. A good example is the automotive industry, which is currently seen as on the verge of a car sharing revolution. This would change the value chain and shift profits from car makers to technological firms, as car brands become less important ("The driverless, car-sharing road ahead," 2016).

Table 8: Subchapter summary: Potential impacts and policy responses related to other policy areas

Issue	Impact	Policy responses
Regional development	Increasing development gap between areas with better access to human capital, investment opportunities and infrastructure (usually urban) and those without (usually rural).	Governments should encourage development in rural areas through: – tax incentives – infrastructure investments
Healthcare	Positive impact due to telemedicine and augmented reality. There are ethical issues with regards to human augmentation, genetic modification.	/
Inequality	Inequality could increase due to job polarization, however not all authors agree.	Policymakers can address income inequality through various methods: – income redistribution – providing equal access to education and other public services

(table continues)

(continued)

Issue	Impact	Policy responses
		– skill development programmes The taxation required for income redistribution can be adapted to today's challenges: – improving tax compliance – addressing the problem of capital accumulation through taxation – robot tax as a way of taxing productivity improvements

Adapted from: Autor, Katz & Kearney (2006); Autor et al. (2017); OECD (2015b); European Commission (2016); European Parliament (2015); Furman et al. (2016); Grinin & Grinin (2014); Manyika et al. (2017); OECD (2015b); Stefan (2015); "The driverless, car-sharing road ahead" (2016); The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company (2017).

Regional development is an issue that policymakers will have to tackle as part of Industry 4.0. Automation and robotization will impact all regions, regardless of whether urban or rural, however, in different magnitudes. In Denmark, for example, the range of impact is within 15 percentage points of the share of work hours, driven by the local sector composition. Rural and less developed areas with more jobs in manufacturing and industry are more at risk of automation compared to urban areas, where there are more jobs in IT, finance and the public sector (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017). Unless addressed by policy, this threatens to exacerbate current regional economic differences and create regions that are "left behind" (Furman et al., 2016). We suggest infrastructure investments and tax incentives as a means to counteract these forces.

Healthcare is another area where Industry 4.0 shows promise but will require action by policymakers. Aging populations in developed countries present a challenge to healthcare systems, both through the associated shortage of physicians and other medical staff as well as the pressure on costs and existing capacities in current healthcare systems (Stefan, 2015). The technological innovations brought about by the Fourth Industrial Revolution present an opportunity to improve the availability of care as well as lessen the financial burden of aging populations through efficient use of existing technologies and a focused development of new solutions. Solutions such as telemedicine and augmented reality are already used in a limited scope and their results are promising. Furthermore, the digitalisation of hospitals, new solutions developed through the integration of technologies, smart machines and software, automation and connected devices are all promising areas for future healthcare development (Javaid & Haleem, 2019).

Finally, inequality is an area where the Fourth Industrial Revolution could present additional challenges. Recent empirical research has increasingly found that technological changes adversely affect the workers in the middle of the income distribution. Autor, Katz, and Kearney (2006) and Autor and Dorn (2013) argue that the routine tasks performed mainly by many middle-skill workers are more efficiently done by AI than tasks that are conducted by low-skill workers, who are now predominately working in service occupations (Hemous & Olsen, 2014). This could lead to a potential job polarization and increasing income inequality (Autor, Katz, and Kearney, 2006; Furman et al., 2016), however, future trends are unclear. The outcomes could either lower the overall inequality or polarize the workers and thus deepen the inequality (Manyika et al., 2017).

The co-interaction of regulatory reforms, globalization and technological change have changed labour markets in a significant manner. However, the burning question of income inequality remains at record high levels in many countries, although there is a steady decline in unemployment. The benefits of the economic recovery are not evenly distributed. The higher income per household and improvement in labour markets did not upset the negative trend of increasing inequality between 2009 and 2015 (OECD, 2015b). Similar findings can be observed from a study that focuses on the correlation between inequality and technological and socio-economic changes resulting from the Fourth Industrial Revolution. The context of each country (France, Germany, Italy, Spain, United Kingdom) was defined by using a set of indicators that carry a significant influence on income inequality (Kuzmenko & Roienko, 2017).

Table 9: Results of correlation between technological and socio-economic indicators and income inequality

Indicators	**Correlation between indicators and Gini coefficient**				
	France	Germany	Italy	Spain	UK
Technological indicators					
Enterprises using software solutions	**0.686**	**0.413**	**0.738**	**0.934**	**-0.379**
E-government activities of individuals via websites	0.294	-0.105	0.276	**0.959**	-0.087

(table continues)

(continued)

Indicators	Correlation between indicators and Gini coefficient				
	France	Germany	Italy	Spain	UK
Individuals using the Internet for ordering goods and services	**0.441**	0.079	**0.636**	**0.922**	**-0.531**
Share of enterprises' turnover on e-commerce	0.206	**-0.731**	**0.710**	**0.914**	0.117
Estimated yearly shipments of multipurpose industrial robots	-0.296	0.206	0.260	**0.601**	-0.091
Socio-economic indicators					
Venture capital investments of GDP	**-0.346**	**0.207**	**-0.459**	**-0.801**	**0.710**
Employed ICT specialists	0.120	0.158	**0.820**	0.190	-0.028
Human resources in science and technology	**0.388**	0.035	0.053	**0.856**	**-0.410**

Source: Kuzmenko & Roienko (2017).

Based on the data presented in Table 9, we can conclude that the factors that influence income inequality the most for all considered countries are: technological indicator – enterprises using software solutions and socio-economic indicator – venture capital investments of GDP. The authors then further conclude that the income inequality under the influence of the Fourth Industrial Revolution in the coming years will grow in countries such as France, United Kingdom and Spain. New technologies tend to complement high-skilled workers and replace low-skilled workers, which means that governments will have to adapt policies to address this growing issue. Germany, on the other hand, adopted an Industry 4.0 Strategy in 2010, which involves a wider range of program initiatives to develop skills that will be required in the future (Kuzmenko & Roienko, 2017).

According to the OECD (2015b), redistributive policies have no impact on growth and lower inequality. Further analyses based on the Programme for the International Assessment of Adult Competences suggest that one major channel that increases inequality are lower investment opportunities (education) of the poorest population. This means that this segment cannot keep up the pace with the constant demand of learning new skills. This must be considered by policymakers who need to involve reforms to tax and benefit policies. It should be considered a re-examination of the tax systems to ensure that the wealthier individuals uphold their fair share of the tax burden. This can be achieved not only by raising marginal tax rates, but also by improving tax compliance, eliminating or scaling back tax deductions that benefit high earners disproportionally, and by changing the role of taxes on all forms of property and wealth. However, it is more important to focus on inequality at the bottom. Social and government transfers are extremely important support channels that promote and increase the access to public services. Investments need to be designed on a long-term basis, which will smooth out the inequality and foster upward mobility (OECD, 2015b).

The increasingly concentrated sales among firms with higher productivity fostered by technology (so-called superstar firms) enabled them to control a larger market share in markets, which are increasingly winner-takes-most, in part due to the transparency afforded by the internet. These companies have amassed a significant amount of capital that is not being put to use ("How to make robots pay their share," 2017). Furthermore, as those firms are much more profitable and therefore will have a smaller share of their labour in total sales or value added. This consequently means that the aggregate share of labour falls as the size of those firms increases. In this case the redistribution policy would increase social transfers and thus reduce the income inequality (Autor et al., 2017).

An alternative option to tackle the rapid automation process is some form of robot taxation. Gates (in "How to make robots pay their share," 2017) argues that slowing the automation process would allow people who would likely fall into long-term unemployment to re-adjust and thus prevent a sudden job loss. This would also allow policymakers to prepare better solutions for the endangered by raising additional funding for new employment opportunities. It would also mean that the automation process would be more regulated and thus the pace could be slowed down. The challenge is going to be how to redistribute income from machines and their owners to displaced workers. The main objective is to share the benefits of automation as widely as possible. Another efficient way to capture a share of the benefits of economic growth is a tax on land without discouraging productive investment ("How to make robots pay their share," 2017).

Finally, the issue of universal basic income as a means of reducing inequality should be considered. Universal basic income is a fixed, unconditional income paid to everyone in a given economy (Bidadanure, 2019). The main aspect of it is that it is not based on income or age. The idea has been discussed for several decades. A prominent example of an actual universal basic income is the Alaska Permanent Fund dividend, which is paid yearly to all Alaska residents since the 1980s. The main purpose was to distribute the rent from oil production (Gupta, 2019). There were also many short and local attempts to all over the world, especially in the 20th century. The early 21st century was characterized by many serious political proposals to induce the universal basic income in Switzerland, Finland, and France (Borgnas, Eskelinen, Perkio & Warleneius, 2015). Universal basic income has the benefit of being a transparent and simple welfare system compared to existing welfare systems in the world today. However, it is also an ideologically charged proposal that has proven difficult to implement (De Wispelaere & Stirton, 2004).

3 THE EFFECTS OF THE FOURTH INDUSTRIAL REVOLUTION ON LAST YARD DELIVERY

In the following chapter, we will present the impacts of innovation as part of the Fourth industrial revolution on a specific area, as a real-world example. The area we selected for this purpose is last yard delivery. The impacts on society and economy are evaluated in terms of policy areas defined in the previous chapters, namely productivity, labour, education, and digital security.

Last yard delivery is a relatively new term, which emerged in the field of logistics mainly as a response to the trend of perfecting the customer's user experience throughout the entire lifecycle of the service, and as the result of increasing demands from the customers themselves. Whereas last mile delivery, a known and widely used term in the world of logistics and supply chain management, refers to the movement of packaged goods from the distribution hubs to consumer addresses (Esper, Jensen, Turnipseed & Burton, 2011), last yard delivery specifically refers the last and shortest, yet most time demanding and most expensive part of the package journey – bringing the packages from the delivery van to the customer's doorstep (Kapadia, 2018; Visinski, 2019).

Last yard delivery is the most inefficient part of the delivery process for two main reasons (Visinski, 2019):

1. It mainly involves single deliveries to numerous locations.
2. A successful delivery is dependent on the physical presence of the recipient.

Unlike the delivery of goods from the sender to the distribution hub, which is carried out in bulk to a limited number of locations, last yard delivery mainly involves delivering single packages to numerous locations - the homes of end consumers. The increased road traffic in urban areas makes delivering packages to a large number of delivery points a very time-consuming activity, but perhaps even more so in rural areas, where the delivery points can be located several kilometres away from one another (Dolan, 2018). Parcel delivery and courier companies are generally obliged by law to deliver to all officially registered addresses, meaning they must deliver the parcel regardless of whether the recipient lives in the heart of a metropolitan area or at the very end of a remote mountain valley.

A widespread solution for both challenges (i.e. reducing the amount of final destinations and successfully delivering packages without the presence of the recipient) are Click and Collect points. Many companies, including a majority of the international courier service giants (e.g. DHL, FedEx, UPS) and state-owned postal organizations (e.g. USPS, Royal Mail, Pošta Slovenije), have introduced such alternative pick up locations, most noticeably the public self-service parcel lockers. These are not an entirely recent innovation, as a broad variety of public lockers is being used today. The parcel locker market is expected to reach a value of

700 million US dollars by 2020 (Norman, 2016). Private parcel lockers, such as Direct4.me lockers, attempt to solve the last yard on a more individual basis. Using private smart home parcel lockers, Direct4.me introduced an ecosystem which connects all parties involved in the e-commerce process, namely online stores, logistics companies and consumers to provide a last yard solution, which always ends with a successful delivery (Visinski, 2019).

Some of the recent attempts to solve the last yard problem have also relied on artificial intelligence and machine learning. Marble, a start-up from California is hoping to revolutionize the delivery, more specifically food delivery industry with a fleet of intelligent autonomous robots who can deliver packages 24/7 and can avoid traffic by driving on the sidewalks (Simon, 2018).

Lastly, the crossroad between technology and logistics cannot stand without mentioning drone delivery. Several companies, including Amazon, UPS and Google have been developing drone delivery solutions for years (Amazon, n.d.; Levin, 2019; UPS Pressroom, 2019). 2019 marked the year when all three companies won certain approvals of certain degrees from the U.S. Federal Aviation Administration (hereinafter: FAA), with Google being the first to reach initial FAA clearance (Levin, 2019) and UPS being the only one to be awarded with the highest level of certification, the Part 135 Standard certification. This allows it to use an unlimited number of unmanned drones to complete the last yard (UPS Pressroom, 2019).

3.1 Productivity impacts

The last yard solutions explained above without exception improve the productivity of the logistics and courier companies.

Click and Collect points and Direct4.me smart home lockers have one thing in common: eliminating the requirement for the presence of the recipient at the time of delivery. To successfully deliver a parcel, the courier is required to receive Proof-of-Delivery from the recipient, most commonly in the form of a signature (Visinski, 2019). Receival of Proof-of-Delivery becomes challenging especially during regular working hours, the time when couriers are primarily delivering the packages and most of the recipients are at work. This mismatch results in many packages being either returned to the warehouses, dropped at local post offices, at alternative delivery points such as petrol stations or even scheduled for a second attempt of delivery (Konstantinov, 2019). Western countries traditionally tried to solve this inefficiency by adopting an unattended delivery method which involves dropping the package at a previously agreed upon place, e.g. at the front door, but this potentially introduces a significant amount of package theft and weather damage. Some of these inefficiencies come at the cost of the consumer while others, such as second attempt delivery, burden primarily the logistics company. Public and home lockers solve these challenges by enabling the courier to conclude the delivery in complete absence of the recipient. In most cases, the courier is granted access to the locker, either digitally or physically, and upon delivering the parcel, the recipient is notified of the successful delivery. Click and Collect points on public locations (e.g., train stations, business parks, apartment complexes) are advantageous compared to home lockers in that they provide an ability to deliver a batch of multiple parcels to one single location, saving time and gas otherwise required to deliver these parcels individually. However, whereas Click and Collect points work flawlessly for the logistics companies, they were not favourably adopted by the consumers. A consumer behaviour study of online shoppers in Slovenia showed that merely 1.1 percent of individuals who qualified as frequent online shoppers have used a public locker at least once in the last 12 months (Episcenter, 2018). The reason behind the poor adoption rate of public lockers lies in the fact that delivering parcels into a relatively remote public location defeats the goal of home delivery – the customer is still required to leave their home. Direct4.me enables consumers to get their parcels delivered at home, even when they are not home (Visinski, 2019). This benefit comes at a cost to the courier company, though, as opposed to public lockers, home lockers require driving to individual homes. Home lockers have proved valuable during the COVID-19 pandemic, as they enable a contactless and impersonal home delivery.

Autonomous vehicles, especially drones, tackle a different inefficiency: traffic. It is estimated that by 2050, the world's urban population is expected to roughly double (United Nations, 2017). This is not only an environmental issue, as the emissions and noise pollution grow drastically with an increase in the amount of traffic, but also a challenge for last mile delivery. The longer the time interval in which a delivery van moves between two individual delivery points, the lower the delivery frequency and the higher the operating costs. That directly corresponds to a reduction in the size of market areas serviced (Weisbrod & Fitzroy, 2011). Furthermore, the availability of on-street parking spaces and freight loading zones are insufficient in certain time periods of the day, primarily during the morning and afternoon rush hour. The lack of available parking spaces results in additional time per delivery spent searching for a parking space and in parking fines. Parking fines acquired from illegal parking are so inevitable in last-mile logistics that they are considered a cost of doing business (Aljohani & Thompson, 2020). The New York City Department of Finance reported that UPS parking fines in 2019 amounted to 33.8 million US dollars in New York City alone (Baker, 2019). The ability to carry out home delivery without the use of congested roads not only increases the amount of successful deliveries but also the punctuality of the deliveries, increasing the customer satisfaction in turn. However, even with regulation, drones still have certain drawbacks as opposed to traditional means of delivery, particularly in terms of capacity. Whereas a courier with a conventional delivery van delivers up to 150 parcels in a regular eight-hour shift (Ghaffarzadeh, 2017), the maximum capacity of an Amazon delivery drone is a single parcel weighting up to 2.27 kilograms (Amazon, n.d.). Mercedes-Benz, knowing this drawback, invested 562 million US dollars into drone start-up Matternet to explore the possibility of a delivery van filled with drones. The van would function as a mobile centre base for the drones, enabling it to move into high density locations, increasing the delivery frequency (Sloat & Kopplin, 2016).

3.2 Labour market impacts

Mass market adoption of self-service parcel lockers could negatively affect the employment rate in logistics and courier companies. Delivering numerous parcels to a single location saves time and effort per delivery and ensures the success in the first attempt (DHL, n.d.) however, compared to regular home delivery, less drivers are required to deliver the same number of parcels. Furthermore, self-service functionality of parcel lockers enables recipients to retrieve the parcels themselves, potentially rendering the post office window clerk profession obsolete.

The demand for delivery persons could be even more drastically affected by the introduction of autonomous vehicles and delivery robots. If we only take UPS for example, it employs a delivery fleet of total more than 125,000 vans, package cars and motorcycles across the world (UPS, n.d.). Replacing these vehicles with an autonomous substitute would leave thousands of drivers unemployed, and if the entire logistics industry would follow this trend, such drivers would hardly find a job at other companies within the industry. However, despite advanced capabilities of autonomous driving or flying, a minority of these vehicles can act in complete absence of human supervision, both from an operational and legal standpoint (European Cockpit Association, 2019). For this reason, companies have already started recruiting certified drone pilots along with repair technicians and system administrators.

3.3 Education impacts

It is imperative that the education of new entrants as well as existing laborers in the field of logistics is adjusted and tailored to support and adhere to the requirements of modern activities to ensure a smooth transition in line with the changes in last yard delivery.

It is the low-class professions, such as delivery persons, who are generally less acquainted with modern technology (Anderson & Kumar, 2019), that will see some of the most evident changes in their everyday set of activities. Information is progressively becoming digitalized and communication with customers and supervisors is moving onto mobile platforms and applications. Using parcel lockers and digital home locks requires beyond basic digital literacy including the use of mobile applications, fingerprint authentication, QR code scanning and near field communication (hereinafter: NFC) transactions (Visinski, 2019). These changes should be reflected in a revised curriculum for secondary and tertiary education. Direct4.me, joined by the Faculty of Electrical Engineering and Computer

Science of the University of Maribor, took an initiative to bring a physical world application of software development closer to programming students. Students were provided with several open-source home lockers and encouraged to explore new possibilities of parcel delivery and some of the best performing students were offered a full-time software development position at Direct4.me (Visinski, 2019). Moreover, retraining and new technology and services workshops should be provided to existing couriers to assist them in using new tools or even transition into a new role. New tools and technology are creating new jobs, too. The Federal Aviation Administration offers certifications for commercial pilots (Federal Aviation Administration, n.d.). Assuming the role of managing the vehicle is a viable alternative for previous delivery van drivers who could potentially be replaced by drones.

3.4 Digital security impacts

Smart lockers are generally unlocked with a mobile application using a wireless communication technology, e.g., Bluetooth or NFC or by manually entering a one-time personal identification number. Putting physical burglarizing aside, these are the potential access points for criminals. Communication security and encryption in the process of sharing access must be established to prevent package theft. Direct4.me home parcel lockers ensure this using a proprietary Data-over-Voice technology. Single time access to an individual locker can only be granted to one MSISDN (Visinski, 2019). When the recipient selects to open the locker, his request is cross-checked in the database and, if the request is valid at that time, a digital key in form of an encrypted sound file is played to the locker and the electronic lock unlocks. Once the key is used, it is expired and can no longer be used. Only a new digital key granted by the owner can reopen the locker. The backend system additionally keeps a record of all requests, enabling the possibility to pinpoint to any illicit activity along with the corresponding MSISDN (Visinski, 2019).

Not only package theft, but also public health is at risk in case of unmanned aircraft vehicles. According to Lloyds Register (2017), there are 6 levels of autonomy in unmanned shipping and delivery vehicles. The third and fourth level assume an ongoing supervision of the vehicle while the fifth and sixth level reduce the human interaction to the bare minimum. The latter, final level, although currently only theoretical, refers to vehicle operating completely autonomously and in absence of any human supervision (Lloyds Register, 2017) The larger the extent of autonomy in decision making, the more imperative it is that the vehicle is secure from external threats. Every commercial unmanned aircraft vehicle and its pilot should always be authorized to fly, be monitored, and have a full record of all its activities. Potential digital security impacts can be mitigated through a precise and knowledgeable assessment of security threats (Fischer, Mathias, Morrill, Döring & Haesen, 2018) and by establishing corresponding measures at all system stages, namely storage, operation, and maintenance. The system should always be updated, free of malicious software and disconnected from public networks. It is crucial that all communication is always securely encrypted (ECA Group, n.d.).

4 COUNTRY POLICIES

Country approaches towards the Fourth Industrial Revolution differ, with many focusing on robotics – it is probably one of its most visible aspects. The policy measures that were explored in the previous subchapter address specific concerns about the outlined trends within the context of the Fourth Industrial Revolution as a global phenomenon. However, the consequences and benefits for countries will differ and subsequently the paths that countries will choose will differ too. Given the large implications of Industry 4.0, it is sensible to consider how to promote further automation and robotization, as well as other trends within the phenomenon, such as artificial intelligence, digitalization etc.

To study the policies related to the Fourth Industrial Revolution, the approaches pursued in Denmark, Germany, Austria, Japan, and Singapore are analysed. The countries are all open, developed economies with some similarities with Slovenia. The countries' international performance, strategies, and other policies, as well as other steps taken are analysed.

Furthermore, in order to provide some overview and comparison, European Union member states were compared using the Digital Economy and Society Index created by the European Commission. According to the European Commission (2019a): "The Digital Economy and Society Index is a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness." The index is further subdivided into six dimensions (European Commission, 2019a):

- Connectivity, measuring the deployment of fast internet infrastructure and its quality.
- Human capital/Digital skills, measuring the skills required to fully take advantage of the digital economy
- Use of internet services by citizens, accounting for various online activities that show a country's level of advancement in the digital economy, such as online banking, online shopping, the consumption of online content etc.
- Integration of digital technology by businesses, an important aspect as businesses can enhance efficiency, reduce costs, better serve customers through digitisation.
- Digital public services, measuring the level of digitisation of public services, primarily eGovernment and eHealth.
- Research and development, measuring the level of such activities in fields, such as ICT etc.

4.1 Denmark

Denmark is home to a strong cluster of robotics companies, well-developed research and educational institutions and more than 80 companies with automation technologies as the core of their business (Kovač et al., 2017; Steno, 2016). The industry is very flexible, targeting niches and using advanced technologies, making full use of a very advanced educational system. This cluster has driven robotization and has allowed Denmark to become one of the most automated countries in Europe (International Federation of Robotics, 2016). According to Invest in Denmark (2019), the reasons for Danish success in the field of robotics are the following: "Denmark has a long tradition of being at the forefront in regard to adopting digital solutions as part of daily life and work. This positive and open attitude towards digital technology is one of the key elements when it comes to an increased use of robotics and automated solutions in companies in Denmark. Of course, also the need for companies to stay competitive on a global marked is of great relevance."

Furthermore, Denmark is one of the best performing nations in Europe on the Digital Economy and Society Index. In its 2019 edition, Denmark came in fourth. In the Connectivity dimension, it is the European leader, with fourth-generation broadband cellular network (hereinafter: 4G) and next-generation fixed internet coverage at 99 and 95 percent, respectively. Rural coverage of fast broadband is at 71 percent, lagging behind urban areas but less than in other countries. In 2018, the Parliament set a target for all homes and businesses to have access to broadband speeds of at least 100 Mbps downlink and 30 Mbps uplink by 2020 (European Commission, 2019b).

In the Human capital dimension, Denmark ranks seventh among European Union countries. It achieved especially good results in terms of digital skills, with 71 percent of Danes having basic skills and almost 50 percent having above basic digital skills. In percentage terms, the share of ICT specialists in the workforce is increasing, too and in 2019 stood at 4.4 percent, ranking eighth in the European Union. Denmark's Danish Technology Pact, an initiative to improve Danes' science, technology, engineering and mathematics skills plans to increase these figures further, especially the number of graduates in these fields, with approximately 6 million euro worth of investments planned between 2019 and 2023 (European Commission, 2019b).

Denmark is the EU leader in the Use of internet services dimension. It ranks particularly high in the share of internet users as well as in the use of various internet services. In the Integration of digital technology dimension, the country ranks high as well, fourth out of 28 member states. Danish companies are among the best in the European Union in the use of modern solutions, such as cloud deployment, online sales, social media and electronic information sharing. In 2018, the country has also launched a new cyber and information security strategy for the 2018-2021 period, aiming to improve technological resilience, knowledge and skills of people, businesses and public authorities, as well as improve coordination and cooperation on information security on the national level (European Commission, 2019b).

In the fifth dimension, Digital public services, Denmark performed well, too, ranking fifth among European Union countries. It leads in online medical data exchange and the availability and usage of digital public services for businesses. The country also scores well in the usage of e-health services and the share of e-government users. The country is committed to digitising its public and health services further. In 2018, the Danish Government launched the Digital Health Strategy 2018-2020 with the aim of helping various healthcare providers improving interconnecting patient pathways across the healthcare system. Overall, the country has a solid foundation, which enables further digitalisation of public and health services (European Commission, 2019b).

Denmark has been at the forefront of public policy development for tackling the Fourth Industrial Revolution. To assess and handle the impact of future developments in automation and other technologies on the labour market, the Danish government established the Danish Disruption Council in 2017. The council is composed of government ministers, chief executive officers, company representatives, social partners, scientists and others (Poulsen, 2018). The work done by the council resulted in a report published by the Danish government in February 2019 on the future of labour in Denmark. The report focused on four key areas of focus for the coming decades (Ministry of Employment, 2019):

1. Higher requirements for the education system of the future,
2. Productive and responsible companies in a digital world,
3. A modern and flexible labour market,
4. Globalisation, foreign labour and free trade.

In the first area of focus, the report identified four challenges: too many Danes are still not getting an education, too few Danes enrol in vocational education programmes, ensuring that the education system matches the needs of the labour market and that the digitalised labour market of the future requires new competences. To address these challenges, the government has reformed preparatory education by establishing a new basic education level for young people under the age of 25 with only compulsory education (Cedefop, 2018b). The government has also earmarked 2.3 billion Danish kroner (approximately 300 million euro) for initiatives to boost enrolment and completion rates for vocational education programmes. Furthermore, the government has launched a new national Science Strategy to get more children and young people to take an interest in the natural sciences and encourage more young Danes to take scientific subjects in secondary or vocational education. Finally, a pilot programme to improve technological literacy in primary and lower secondary education compulsory curriculum was started for the 2018-2021 period. The pilot programme will test different models for improving technological literacy in schools and the curriculum. The government plans to assess the need for improvement based on the findings of this pilot (Ministry of Employment, 2019).

In addition, a change to how higher education functions was deemed to be needed. The changes identified and agreed upon were the need for more flexible university degree programmes, a new research and innovation policy and new objectives for higher education programmes, which are as follows: High academic level and significant learning outcomes that foster motivation, knowledge and critical thinking, close links between the higher education programmes and society's current and future competence needs, and a well-educated population with many years in the labour market. These objectives will help policymakers create new initiatives and measures to shape higher education in the future (Ministry of Employment, 2019).

In the second area of focus, Productive and responsible companies in a digital world, the Danish Disruption Council's 2019 report identified six challenges: the risk of Danish companies falling behind internationally, data ethics uncertainties compromising trust in digital solutions, platform and sharing companies requiring new legislative standards, digital platforms with very high market shares posing a threat to competition, lack of talent threatening to weaken companies' growth and lack of access to capital, which can hamper the business community. To address these identified challenges, the Government is launching three new initiatives. The first has the goal to promote ethical and sustainable use of data in companies to ensure that companies work with data in a responsible manner. The second is to strengthen the competition and consumer protection authorities to help smaller, Danish companies operate in the digital market, dominated by established online platforms. The third initiative is the adoption of a national strategy for artificial intelligence to ensure Denmark takes the lead on a responsible development and application of artificial intelligence (Ministry of Employment, 2019).

The third area of focus, A modern and flexible labour market, is a particular area of interest for the Danish government due to its longstanding model of collective agreements between employers and labour unions and flexicurity system, enabling high job turnover. The Danish Disruption Council has identified three challenges that need to be addressed with regards to Denmark's labour market (Ministry of Employment, 2019).

The first challenge is establishing the requirements to enable transitions to less automatable jobs and promote lifelong learning. According to The Tuborg Research Centre for Globalisation and Firms and McKinsey & Company (2017), 40 percent of the total hours worked in the Danish labour market can be automated via existing technologies. However, the number of jobs that can be completely automated away remains low. The greatest effect will thus be in revised and upgraded job descriptions, which will reduce the share of menial automatable tasks and increase the share of social, creative or otherwise less automatable tasks. The Danish Disruption Council finds that the labour market is well-prepared to cope with this transition, however there is a group of several hundred thousand employees whose existing job tasks may be automated to a large extent (The Tuborg Research Centre for Globalisation and Firms & McKinsey & Company, 2017)

The next challenge is presented by the rise of digital platform companies and the sharing economy. These platforms cater to a growing demand for flexible services in a variety of markets. Whilst the platforms do provide a more flexible working life as well as an easier access point to work for people who struggle to find employment, the nature of the work that is done through these platforms challenges the concepts of the traditional labour market. Therefore, the Danish Disruption Council recommends that the developments in this area are closely monitored and inclusive solutions are found in cooperation with social partners when new challenges arise (Ministry of Employment, 2019).

Finally, the risk of greater social divisions unless everyone takes part in progress is identified. Ensuring technological progress and globalisation does not exacerbate societal inequalities benefits individuals as well as society in general. The Danish Disruption Council recommended that the government continually strive to ensure that the Danish labour market remains flexible and resilient. Furthermore, it has been recommended that efforts are made for upgrading existing skills and qualifications, targeting people seeking work through unemployment job centres as well as helping companies with labour shortages and enabling more flexible labour market access for the most disadvantaged unemployed (Ministry of Employment, 2019).

The fourth area of focus is globalisation, foreign labour and free trade. While Denmark greatly benefits from globalisation and access to foreign labour, several key challenges have been identified. The first challenge is reduced productivity growth, which can lead to economic stagnation. Denmark has seen reduced levels of productivity increases for a number of years (Jensen & Nguyen, 2016). The second challenge is a lack of qualified foreign labour. While Denmark has mostly relied on the European Union internal market for its labour needs, due to increased international competition and diminishing wage differences between European Union member states, it is becoming increasingly more difficult to recruit labour from this market (Ministry of Employment, 2019). Therefore, the Danish Disruption Council identifies the need to actively promote employment of workers from outside the Single Market. The third challenge that has been identified is the rise of protectionism across the globe. This phenomenon presents a threat to small open economies, such as the Danish economy (Douglas, 2018). International trade plays a major role in the economy with Danish foreign trade amounting to around 100 percent of gross domestic product (Ministry of Employment, 2019).

To combat these challenges, the government is strengthening efforts to ensure proper and regulated conditions in the labour market, supporting an increase in productivity among businesses, ensuring better retention of international graduates by better links between educational institutions and the labour market, creating the position of Tech Ambassador to head the new policy focus area of technological development and its impacts on Danish society and ensuring that Denmark remains an open trading nation. Furthermore, the Danish Government will introduce reform proposals to improve recruitment of foreign labour by making the process quicker and more flexible (Ministry of Employment, 2019).

While Denmark has ensured that its policy development keeps up with technological and societal changes, its businesses have continued to stay competitive in the main areas of the Fourth Industrial Revolution. Robotization in Denmark has progressed in the bottom-up approach through organic development in the Odense cluster (Kovač et al., 2017). This is similar to Slovenia, where robot adoption is also growing organically in a bottom-up manner (Lenarčič in Koman et al., 2017). However, in order to help sustain the country's high quality of life, high, robot-supported productivity is required. To ensure this, the movement was followed by a concerted effort to develop robotics further, where the government again had a constructive role (Steno, 2016).

The flagship of the robotics cluster is Universal Robots, a company that specializes in collaborative robots (Steno, 2016). In 2008, it was a failing start-up until it received a financial injection and new management by a state investment fund and later on, the company's development was assisted by a state innovation fund, as well as clear local government support (Innovation Fund Denmark, 2017; Steno, 2016; Vaekstfonden, 2017). The company's history thus highlights the importance of effective and smart government policy for cluster development, which Denmark is successfully pursuing.

4.2 Germany

Germany is the fifth largest robot market in the world and the country with the highest robot density in Europe (International Federation of Robotics, 2016). The country's approach to robotization can be characterised as much more top-down than Denmark's. The formulation of the strategy started at the Federal Ministry for Economic Affairs and Energy, which addressed the rapid technological changes through the creation of a nationwide Industry 4.0 strategic initiative, thus beginning an active push towards robotization in the manufacturing sector (Plattform Industrie 4.0, 2017).

The German federal government sees Industry 4.0 as a major opportunity for Germany to establish itself as an integrated industry lead market and provider. The basis for this strategy are two goals; (1) Germany to become one of the world's most competitive and innovative manufacturers, and (2) Germany becoming a technological leader in industrial production research and development (Germany Trade and Invest, 2017). However, despite some investments by Germany's largest companies, business in general has not responded to the challenge, with SMEs (the so-called *Mittelstand*) proving particularly problematic in terms of awareness and readiness (Karnitschnig, 2016). To address this issue, the “Mittelstand 4.0” initiative of competence centres the Go-Digital programme have been launched in 2018 to improve the degree of digitization among medium-sized companies and enable easier access to consulting services for SMEs in the area of digitised business processes, digital market development and digital security (European Commission, 2019c).

Furthermore, Germany has not been a top performer among European Union countries in terms of digitalisation, ranking 12th out of 28 European Union member states in the European Commission Digital Economy and Society Index 2019. While the country performs well in most dimensions of the index, the use of e-government and e-health services, as well as access to ultrafast broadband are lacking. Overall, the country’s advantage over the European Union average has faded in the 2014-2019 period (European Commission, 2019c).

In the Connectivity dimension, Germany has made progress in most indicators, however its progress has not been as fast as other countries’, especially with regards to the quality of its internet infrastructure, specifically the take-up of fast mobile technologies such as 4G and ultrafast broadband, where the companies, where the country is 24th and 19th, respectively. There is a notable urban-rural digital divide in the country regarding fast broadband and the share of fibre connections is still very low, with telecommunications companies focusing on improving existing connections rather than deploying new fibre networks. This has implications for the competitiveness of companies, especially companies located in rural areas and focusing on the digital economy or that are otherwise reliant on good connectivity to conduct business activities. On the other hand, Germany performs well in the take up of fixed broadband, the readiness for fifth-generation broadband cellular networks (hereinafter: 5G) in terms of assigned spectrum and enjoys some of the lowest prices for broadband access in the European Union (European Commission, 2019c).

In the Human Capital dimension, Germany fares better, ranking 10th among European Union countries, doing especially well in the share of individuals with digital skills and with software skills. Despite a not insignificant share of ICT specialists, the country is still facing a lack of this profile. The Federal Government sees digital skills and literacy as an issue that has an important role in both digitisation and artificial intelligence strategies (European Commission, 2019c).

In the Use of internet services dimension, Germany performs well despite its infrastructure issues. Germans are engaged in various online activities more than the average European, especially shopping and selling online (ranked 5th and 3rd in the EU, respectively). On the other hand, news consumption and social network use are among the least used in the EU (27th and 21st respectively) (European Commission, 2019c).

In the Integration of digital technology dimension, Germany ranks 13th in the European Union. Like among individuals, social media use among enterprises lags behind most European counterparts and has fallen in the 2017-2019 period, with Germany ranking 20th in this indicator. The share of small and medium-sized enterprises selling online has fallen sharply from 26 percent in 2017 to 19 percent in 2019. However, Germany's ranking with regards to this indicator remains relatively high at 10th place. Furthermore, cross-border selling and big data usage are above the European Union average and increasing, with Germany ranking 7th and 9th, respectively (European Commission, 2019c).

Germany's performance in the Digital public service dimension is the poorest of the five dimensions. The country ranked 24th among European Union countries in 2019 and the gap with the average has been widening. The share of e-Government users and e-Health services users is particularly low, as is the availability of digital public services for businesses. To address this issue, the Online Access Act came into force in 2017 with an implementation deadline by 2022. The act stipulates that administrative services will also be offered electronically via the administrative portals of the Federal Government, the State Governments and municipalities, which will have to be linked to a portal network. Similar efforts are being made with regards to e-Health access, however the country is still lagging behind its European counterparts in both areas (European Commission, 2019c).

The Federal Government has prepared a Digital Strategy to prepare the country for the future as well as possible. Part of the initiative is an earmarked sum of 3 billion euro for investments in artificial intelligence technologies by 2025, with an expected equal amount of private investment (Brady, 2018). The Digital Strategy is a package of measures in five fields of action: digital skills, infrastructure and employment, innovation and digital transformation, society in digital chance and the modern state (Federal Government, 2018).

The Digital Strategy outlines ten steps that the country must take to remain competitive in a rapidly digitising and automating world: creating a gigabit optical fibre network, assisting start-ups and encouraging cooperation between young and established companies, creating a regulatory framework that facilitates investment and innovation, encouraging smart networks in key commercial infrastructure areas, strengthening data security, enabling new business models for SMEs, utilising Industry 4.0 to modernise German manufacturing, creating excellence in innovation and research and development (hereinafter: R&D), introducing digital education and creating an independent digital agency (Federal Ministry for Economic Affairs and Energy, 2016).

In order to address the handicap to its economy presented by the comparatively poorer connectivity due to the lacking quality of its fixed and mobile broadband infrastructure, the country aims to create a nationwide gigabit optical fibre network. According to Jay, Neumann and Plückebaum (2011), the nationwide deployment of a fibre-to-the-home (hereinafter: FTTH) network will require investments of up to 100 billion euros. While the market is expected to drive an expansion of gigabit networks in urban areas, rural areas remain in danger of falling behind. Therefore, an investment fund for optical fibre networks in rural areas is planned to be established by the government, providing funding of 10 billion euros by 2025, funded in part from future 5G spectrum auctions (Federal Ministry for Economic Affairs and Energy, 2016).

Germany is one of the world's leading industrial locations. Manufacturing and manufacturing-related services generate over half of the gross domestic product of the country. Industry digitisation is projected to open up potential additional cumulative value added of 425 billion euros, improving productivity by up to 30 percent and account for annual efficiency gains of 3.3 percent as well as annual cost reductions of 2.6 percent. The sectors that are projected to benefit the most from digitisation and automation over the period between 2016 and 2021 are the automotive industry, mechanical engineering, process industries, the electronics industry and ICT (Federal Ministry for Economic Affairs and Energy, 2016).

According to the Federal Ministry for Economic Affairs and Energy (2016), in order for Germany to develop and utilise the potential provided by Industry 4.0, the following conditions must be fulfilled:

- Assistance programmes for SMEs must be established and utilised in order to raise awareness, provide information and finance investments.
- Introduction of funding programmes for microelectronics, in particular a European research and innovation project for the development of microelectronics in the amount of 1 billion euro.
- Implementation of recommendations by expert groups in the areas of standardisation, legal framework, IT security and work, addressing issues such as secure identities and secure trans-company communication, the necessity of further development of machine guidelines, standardisation requirements and qualification or awareness enhancement for employees.
- Development of an Action Plan for Standardisation of Industry 4.0.
- Strengthening cooperation on an international level through bilateral cooperation with important partner countries, such as China and the United States.

German companies invest 14 percent of their annual research budget in commercial applications for digital technologies, while companies in the United States generally spend twice as much on average (Federal Ministry for Economic Affairs and Energy, 2016). This relationship holds true for European Union countries on average, too. The European Union shares of research and development expenditures in medium-tech sectors are higher than those of China and the United States, while high-tech sectors have a significantly higher share of R&D expenditures in China and the United States than in the European Union

(European Commission, 2019d). The Digital Strategy of the German federal government therefore posits the necessity of broadening digital research efforts, especially in traditional industries, particularly in the areas of Industry 4.0 and Big Data. A need for a substantial increase in funding for research and development of digitisation of the economy and an increase in tax advantages for research expenditures among SMEs is also noted in the Digital Strategy.

The challenges posed by the Fourth Industrial Revolution and digitisation to the education system are an issue that many governments are considering. Similarly, Germany's Digital Strategy outlines the need for a Digital Learning Strategy that will be supported by all stakeholders, not just businesses and politicians. The Digital Strategy sets out the following goals to be achieved by 2025: every school pupil should have basic knowledge in information science, how algorithms function and in programming; Germany will be one of the leaders in digital infrastructure in the education sector; the workplace should be the number one place to acquire the newest IT knowledge; all publicly financed educational institutions should make essential teaching materials available online (Federal Ministry for Economic Affairs and Energy, 2016).

The overarching goals have been divided further into goals for each education level as well as for lifelong education. The goals for school educations are for German schools to catch up with international leaders in using digital media, strengthen the bond between companies and educational institutions through activities such as sharing innovation and knowledge management concepts developed in business with educational and start-ups in the education sector that use digital platform to enhance access to the creative potential and expert knowledge of teachers should be assisted by the state (Federal Ministry for Economic Affairs and Energy, 2016).

The existing dual system of vocational training, which is a cornerstone of the German industrial model, is presented as a guarantee for quality and innovation ability. In order to ensure its relevancy in the future, further goals have been set (Federal Ministry for Economic Affairs and Energy, 2016):

1. Alignment between the dual system of vocational training with the demands of the digital economy
2. Industry-wide continuing education centres should offer further training in digitisation
3. Strict orientation of vocational training for IT jobs towards required practical skills to increase the attractiveness of graduates as an alternative to university graduates.
4. Constant identification and implementation of new trades as well as adaptation of existing trades to best serve the changing economy and employer needs.

Universities are the nucleus of digital innovation according to the Digital Strategy. Therefore, the goals set by the strategy aim to both increase the proliferation of digital interdisciplinary areas into other majors as well as strengthen existing institutions in STEM fields. The goals outlined are thus (Federal Ministry for Economic Affairs and Energy, 2016):

1. Promoting the establishment of additional academic chairs and strengthening the available excellence institutions in STEM areas, particularly in information science, Big Data analysis, industrial software and IT security, especially through cooperation with business.
2. Fields of study such as information systems, data analysis and the Internet should be included in other majors, especially in business schools and in law, political science and other social science disciplines, coupling scientific-technical capability with economic-political evaluation and regulation competencies.
3. Expansion of programmes for funding business formations at universities.
4. Better integration of e-learning into university studies.

Finally, continuing education throughout one's working life is key to lifelong learning and a successful transition in Industry 4.0. The Digital Strategy outlines several goals to be achieved to ensure this (Federal Ministry for Economic Affairs and Energy, 2016):

1. Creation of more flexible and individualised digital continuing education through collaboration with social partners (trade unions and employers) in order to provide employees with industry-wide practical IT-related basic and supplemental knowledge on communication and project work.
2. Achieve a greater take-up of digital skills training for employees in SMEs by adopting measures that facilitate the involvement of SMEs in digital continuing education such as the Mittelstand 4.0 Centres of Excellence.
3. Further development of evaluation and certification systems for continuing education for employees without access to company continuing education programmes.
4. Expansion of media literacy to ensure citizens are empowered to responsibly use Internet resources to effectively continue learning on their own.

Digital security has also been a focus for the German federal government as well as its industry. The government has set its first digital security strategy in place in 2011 and updated it in 2016. Furthermore, in 2018, a digital security advisory organisation called Cyber-Alliance was established by the Federal Ministry of the Interior in cooperation with the Federation of German Industries. The goal of the organisation is to promote key technologies for safeguarding critical business processes and thus ensuring Germany's "digital sovereignty". Furthermore, the government recognises the importance of raising awareness of digitisation and the importance of digital security among SMEs, which will enable the achievement of the full range of benefits to SMEs from the adoption of advanced digital technologies (European Commission, 2019c).

In 2019, the Federal Ministry of the Interior and the Federal Ministry of Defence also set up a joint digital security development agency, called the Agency for Innovation in Cybersecurity. The purpose of the institution is to promote and support ambitious digital security research projects with a high innovation potential, as well as related key technologies, in order to meet the state's needs in domestic and external security and to ensure Germany's technological leadership (European Commission, 2019c).

4.3 Austria

Austria's adoption of robots has been spearheaded by a limited number of industries, chief among which is the automotive industry, as well as an active science community, especially its network of research and educational institutions (Kovač et al., 2017). Austria's approach can be characterized as much more top-down than Denmark's and is similar to Germany with the government's active role in the promotion of Industry 4.0 (Roland Berger, 2014).

In terms of digital economy, Austria performs similarly to Germany, placing 13th on the 2019 Digital Economy and Society Index. While the country remains slightly above the European Union average, the distance to the best performing countries has increased. Much like Germany, its performance compared to the European Union average has faded in the 2014-2019 period (European Commission, 2019e).

In the Connectivity dimension, Austria ranked 16th. Fixed and fast broadband coverage (98 and 91 percent respectively) is above the EU average whereas ultrafast coverage stands at 58 percent and 20th in the European Union, with ultrafast broadband take-up being only 7 percent of households and thus ranked 24th among European Union countries. On the other hand, Austria displays high levels of 5G readiness (ranked 7th), 4G coverage (ranked 8th) and broadband prices far below the European Union average (ranked 4th). The country plans on achieving 70 percent coverage of ultrafast broadband in metropolitan areas in 2020. In terms of mobile broadband, the country is considered a top performer, however in terms of fixed broadband access, more effort is required. The Ministry of Transport, Innovation and Technology is preparing a new broadband strategy for 2030, which could play a role creating the right conditions and incentives for more investments in fixed networks (European Commission, 2019e).

In the Human Capital dimension, Austria ranked 8th, performing well in terms of digital and software skills. The main challenge remains ensuring a steady stream of ICT graduates to the workforce and increase the attractiveness of ICT to women (European Commission, 2019e).

Gönenç and Guérard (2017) have also concluded that Austria is continuing to lag behind other high-income small open European economies in the transition to a digital economy and society. Firstly, the potential for digitalisation in all firms and especially in SMEs is stunted by a lack of ICT skills in the workforce. Furthermore, Gönenç and Guérard (2017) note that the business environment in Austria is not conducive to firm entry and exit, which is hindering the digitalisation of the economy as the entry of new firms and their growth are crucial for the diffusion of new business models and ICT innovation.

One of the main champions of Industry 4.0 in Austria is the Association Industry 4.0 Austria, founded by the Federal Ministry for Transport, Innovation and Technology, the Association for the Electrical and Electronics Industries, the Association of Metaltechnology Industries, the Austrian Federal Chamber of Labour, the Austrian Trade Union for Production Workers and the Federation of Austrian Industries. The objectives and tasks of the organisation include to leverage interests between industry, science, policymakers, employers and employee organisations, provide knowledge and services on Industry 4.0 to companies, universities, research organisations and to the general public, define fields of action and to advise policymakers, to develop strategies with high leverage and enable the exchange of experience, best practices, data and studies, among others (Association Industry 4.0 Austria, 2018).

Austria is home to several AI and robotics research institutions, ranging from basic research to the prototype development, as well as covering a wide range of specific topics (Austrian Council on Robotics and Artificial Intelligence, 2018; Čas, Rose & Shaker, 2017). However, despite the expertise available in the fields of robotics and AI, Austria lacks an overarching strategy with a clear vision (Pichler et al., 2017). To respond to the challenges in a more systematic way, the Federal Government is in the process of finalizing a new national AI and robotics strategy (Wiesmüller, 2019). The process of creating a new strategy began in 2017 with the establishment of an advisory organisation, the Austrian Council on Robotics and Artificial Intelligence. The council is organised as an advisory board of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. Members of the council include experts from academia, specifically from business, computer science, philosophy, psychology, law and industrial engineering, as well as representatives from the labour chamber and the industry. In 2018, the council published a white paper (Austrian Council on Robotics and Artificial Intelligence, 2018), in which it identifies the highest priorities for developing a smart strategy for robotics and artificial intelligence. The white paper identified three cornerstones for an Austrian robotics and AI strategy as well as four fields of action that are considered of the highest importance based on the then-current state of research.

The first identified cornerstone is smart governance, specifically the notion that all Austrians should benefit from the nascent technologies by ensuring that a broad participation of all stakeholders is achieved in the strategy creation process. The second cornerstone is smart innovation. The white paper argues that there is a need for a targeted research, development and investment policy to leverage the potential of robotics and AI technologies in all areas of application, especially given the size and structure of the Austrian economy, which is characterised by a strong SME presence (Austrian Council on Robotics and Artificial Intelligence, 2018). Furthermore, significant targeted public investment, measures to promote innovation and infrastructure development for the use of these technologies are necessary (Federal Ministry of Transport, Innovation and Technology, 2018). The white paper addresses the issue of a lack ICT-skilled workers by recommending the introduction of systematic training measures to ensure the availability of skilled workers and extensive training programmes in order to successfully retrain existing workers. Due to the present major technical challenges and the not yet fully understood or accurately predicted impacts of the new technologies in question, potential industries and application areas which permit rapid implementation and enable a fast learning process are recommended to be implemented as quickly as possible. Finally, the usage of sandboxes is deemed to be warranted for sensitive and/or high-risk application areas to mitigate any negative impacts and to provide rapid learning cycles and knowledge transfer. The third and final identified cornerstone is smart regulation. There is a marked need for a stable and secure framework to ensure the trust of all economic players and continued market development. Furthermore, personal safety, the upholding of ethical standards and values as well as fundamental human rights must be guaranteed throughout the use of robotics and AI technologies (Austrian Council on Robotics and Artificial Intelligence, 2018).

In terms of fields of action, the council prioritised four fields of action to serve as a basis for the development of a robotics and AI strategy. The first field of action is technology, R&D and economy. International competitiveness is recognised as the basis of Austria's prosperity. However, the economy's competitiveness should be maintained through a framework that allows companies to succeed in global competition by facilitating economic stakeholders' willingness to innovate and invest. In small high-wage countries, companies must occupy creative niches and build on existing strengths (Buckley & Hashai, 2004). Areas where knowledge transfer between the academic fields (knowledge generation) and commercial fields (knowledge utilisation) is already strong should be further consolidated and consistently developed with the help of robotics and AI. The limited size of research landscapes in countries such as Austria, as well as the scarcity of available human and financial resources requires a clear definition of priorities and focus on application areas which are most relevant for the economy (Federal Ministry of Transport, Innovation and Technology, 2018). Policymakers must consider both the potential of large corporation and the potential of SMEs, which are one of the cornerstones of the Austrian economy and it is essential that key businesses are involved in the strategy process from the start. The strategy should account for providing the foundations of development that bolsters prosperity, including efficient infrastructure, business-friendly and innovation-promoting conditions, including access to data as a business resource. Furthermore, it is expected that in the future, robotics and AI technologies will become pervasive with deployments in many areas of life. Overall, it is assumed that tasks requiring high levels of dexterity, flexibility and sensitivity in addition to cognitive abilities will remain more difficult to automate than tasks that can be performed with purely software-based systems. Systems will be able to perform many tasks autonomously, which entails some hazards. Besides general safety hazards that arise from robot use such as collisions and manipulation, autonomous systems that are based on machine learning algorithms present an additional set of risks. Legal positions will need to be formulated on how to solve these issues on a case by case basis, especially with regards to liability (Austrian Council on Robotics and Artificial Intelligence, 2018).

The second field of action is the workplace and qualification. As robotics and AI advances promise deep changes to the economy and society, changing both life and work situations, new ways of thinking, working practices, new ways to cooperate and additional skillsets are required. Basic digital literacy is a prerequisite, while innovation and creativity, logic and integrated thinking become more relevant, as do empathy, social, intercultural and communication skills. Thus, the working world of the future is considered a key field of action that should be addressed by the strategy. The Austrian Council on Robotics and Artificial Intelligence (2018) holds the opinion that automation potentials tend to be overestimated but that it is important to identify risks to worker wellbeing as well as potential benefits. Short, medium and long-term measures should be developed to cope with the expected changes to the nature of work, the first of which should be training and re-training measures to alleviate the lack of skilled workers in the economy. A reorientation of vocational education and training towards mechanical engineering, mechatronics, automation technology, electrical engineering, mathematics, information technology and statistics is warranted, as are interdisciplinary skills. As the skills required for future jobs are likely to remain in constant flux, the willingness to learn, flexibility and the ability to assess unclear situations will be required at all education levels. The council also pays particular attention to gender-relevant aspects when developing an education and training strategy as women are underrepresented among STEM graduates. The continued dismantling of barriers to career development, both implicit and explicit, must continue to ensure sustainable and responsible development. Finally, the responsiveness of the education and training system must improve in view of rapid technological change, broadening education and training beyond formal institutions (Austrian Council on Robotics and Artificial Intelligence, 2018).

The third field of action is law and society. As the use of autonomous robots and AI systems spreads beyond production, manufacturing and other highly specialized work environments to social context such as nursing and healthcare, customer care or leisure, with some taking on a humanoid appearance, it is necessary to review the existing ethical and legal framework with regard to psychological, social and socio-cultural changes and introduce new regulations and standards, which guarantee the safety of use of robotics and AI, if necessary. Furthermore, the Austrian Council on Robotics and Artificial Intelligence outlines the trend towards collaborative robotics, which brings another set of challenges and opportunities to the economy and society at large. Furthermore, the wider use of robotics and AI in social settings poses further ethical questions, such as the reproduction of existing stereotypes and prejudices in data as does predictive analytics, the quality of which will depend strongly on the quality of the training data. The council also notes a clear need for local regulation and the need to proactively incorporate appropriate proposals into European legislation. In addition, autonomous system decisions should be checked for compliance with legal and ethical standards and the council recommends the development of appropriate certification and auditing or compliance tools specifically for robotics and AI technologies (Austrian Council on Robotics and Artificial Intelligence, 2018).

Finally, the fourth field of action is awareness raising, communication and public relations. As the topics of robotics and AI technology increase in visibility among the general public, they are often met with a lack of understanding, as often only specialists understand the technical functionalities of the technologies. This lack of understanding exacerbates doubt and fear among the general public, leading to potential negative effects dominating discussions instead of potential opportunities. Thus, it is important that people are provided with reliable and comprehensive information, as citizens must be reasonably informed to be able to assess the opportunities and risks posed by these nascent technologies. A broad participation of citizens is also required for the successful creation and implementation of a national robotics and AI strategy (Austrian Council on Robotics and Artificial Intelligence, 2018).

The Austrian Institute of Technology (2017) developed four scenarios of future labour market development in Austria during the Fourth Industrial Revolution based on eight key factors: societal willingness to use digital technologies, the progress of automation of industry, the ability to develop new products and services that can provide impetus for employment development, general economic growth, the availability of appropriately trained workers, the adaptation of the education system to new and future qualification requirements, the development of data protection and security and Austria's positioning in international competition. The scenarios are as follows (Austrian Institute of Technology, 2017):

1. "Industry 4.0 frontrunner" scenario, where all key factors are positively expressed.
2. "Slow transformation" scenario, where new technologies are slowly adopted in Austria compared to international competition and the country begins to lag behind and experience bottlenecks in terms of skilled workers as well as with regard to data protection and legal security.
3. "Efficiency increases" scenario, where increasing digitalisation is primarily used as a means of business simplification and increased efficiency without any new products, services and business models emerging.

4. “Digital failure” scenario, which assumes that digitalisation will only prevail in a few areas and niches, whereas large parts of the economy and society will not adopt innovative and practical applications of Industry 4.0.

The latter two scenarios are projected to lead to a reduction in manufacturing employment and little employment growth in other sectors, whereas under the slow transformation scenario, the number of jobs could be maintained only under favourable economic conditions. However, a net loss of jobs would be more likely in this scenario, too. Therefore, adaptive and preventive strategies are necessary to avoid these negative scenarios and achieve the frontrunner scenario (Austrian Institute of Technology, 2017).

Despite the positive outcomes of the frontrunner scenarios, shifts in the labour market are to be expected. Furthermore, across all scenarios, the level of education of the population and employees are fundamental to addressing digitalisation risks. The successful transformation of the education system is based on establishing sufficient basic skills, establishing digital understanding in all teaching subjects and compulsory IT subjects. Furthermore, a need to anchor training activities in companies is recognized and modernizing industries requires a great deal of creative effort, openness in the organisational structure and the active involvement of employees and their skills (Austrian Institute of Technology, 2017).

Austria has also explored the implications of Industry 4.0-related on political processes, specifically in the Austrian parliament, strengthening its role as a forum of informed debate about the opportunities and challenges represented by the implications of Fourth Industrial Revolution-related innovations. A dedicated foresight and technology assessment support function for the parliament has been tested through a pilot project. The results of the workshops are proposals for improvement of digital security and education frameworks. In terms of digital security, four solutions have been outlined: establishing a legal framework for data protection, privacy and big data, expanding scientific and technological skills, establishing structures and organizations for information exchange and risk management and the creating awareness of and trust in security solutions (Weber, Gudowsky & Aichholzer, 2019).

4.4 Japan

As one of the leaders in the world of robotics and automation, Japan aims to spread the use of robotics beyond just the large-scale factories to every corner of the economy and society (Fensom, 2015), and doing so, establish and maintain the country’s position as an international superpower in the field of robotics (Edwards, 2015). Since the start of the popularization of commercial robot use in manufacturing, Japan has successfully and rapidly applied robots to various industries. Industrial robots in Japan have traditionally compensated for the lack of labour force in certain industrial professions, which emerged as a response to the high international demand due to the success of Japanese automotive industry in the 1980s (Kusuda, 1999) as well as a compensation for lower birth rates and aging population. Japan ranks as number two in the world with regards to adoption of industrial robots and having utilized more than 300,000 robots in its manufacturing in 2017 (International Federation of Robotics, 2017), falling behind only China. Japan's robot industry produced a total of 56 percent of the entire global supply of robots in 2017. This makes Japan the world's leading industrial robot exporter and manufacturer. It is expected that the Japanese robotics market will increase in size from 5.47 billion to 20 billion US dollars by 2020 (Kemburi, 2016) and provide a significant boost to its productivity in manufacturing, supply chains, construction and infrastructure maintenance, and healthcare (Ministry of Economy, Trade and Industry Japan, 2015). Sirkin, Zinser & Rose (2015) estimate that as a result of robot adoption in Japanese manufacturing, in five years, their labour costs could be as much as 25 percent lower than they are today.

Contrary to the situation in most economies, Japanese workers were not uneasy about the fact that automated robots could eventually end up replacing the human labour force. This was the case mainly due to an implicit employment security contract called "lifetime employment" or *shūshin koyō,* which dates to the start of the 20^{th} century. The corporate loyalty understanding ensures a mutual exchange of assurance, promise and responsibility. In practice, this means that employees would not be enticed by competitive companies and, in return, employers would not resort to employee contract termination even in times of financial crisis (Blomström & La Croix, 2005). As the mutual assurance between the labour force on one hand and the employers on the other was strong, Japanese workers were not threatened by the potential influx of automation into Japanese market and were more accepting to the ideas of introducing a robot labour force. Japanese policymakers see robots as a complementary workforce rather than an opportunity to replace the workforce with cheaper labour. That trend, albeit partly declining, still largely holds true. Even though Japan utilizes approximately 300 robots per 10,000 employees, which is one of the highest ratios in the world, it also has the lowest unemployment rates among the most advanced countries (Komal, 2018). Moreover, cooperation between robots and workers also means that manual labour is not only limited to the male population, as the robot takes over the hard and dangerous work, leaving the worker to undertake a more supervisory job of managing and operating with the robot, a more gender-neutral task. Reducing the amount of manual labour also means that these workers suffer less from back pain and stress. However, as a result of a continuously aging population and a slowdown of the economy, it is projected that by 2040, Japan's workforce will be 20 percent smaller than it is today, so robot adoption is not only an improvement over the current situation in Japan, but largely starting to also become a necessity (Fleming, 2019).

Another reason behind the Japanese success in the field of robotics lies in the fact that the idea of a robot-fuelled future receives a constant support from the Japanese government. In order to counteract the aging of the population, falling birth rates and the decline in productivity, Prime Minister Shinzo Abe turned to businesses in 2014 with a government funded five-year plan named “New Robot Strategy” (Headquarters for Japan’s Economic Revitalization, 2015). The strategy saw participation of more than 200 business within the first year and included some the industry giants such as Honda, Toyota and Panasonic.

At its core is the Robot Revolution Initiative (hereinafter: RRI). Today, RRI is backed and signed by more than 400 companies and other relevant organizations (Kubo, 2016). Various experts were recruited to establish the Robot Revolution Initiative Council, a concept not only based on the German Industry 4.0 model, but also intended to support international collaborations, most importantly with Germany (German Research and Innovation Forum, 2015).

RRI is based on three pillars (Headquarters for Japan’s Economic Revitalization, 2015):

1. A body which encourages innovation through public-private partnerships,
2. A regulatory framework which ensures the safety of the big data generated by interconnected devices,
3. Societal, environmental, and infrastructural development to support widespread adoption of robots.

The goal is to maximize the potential benefits and the growth of robotics and related advanced technologies, both locally and globally. It is designed to achieve that by supporting and promoting collaboration between privately owned tech companies and Japanese government agencies, and by establishing international cooperation to provide circulation of relevant information and best practices and to align interest and readiness to prevent potential disasters (Headquarters for Japan’s Economic Revitalization, 2015).

If robots are to play an important role in the society, it is imperative to take precautionary measures and ensure safety with comprehensive laboratory and field testing. To that end, government collaborated with research institutes and university research and development labs to provide an environment for testing and certification of various types of robots, including infrastructure robots, life support robots and disaster response robots. Additionally, it aims to create and share robot-specific standards with rules and guidelines for privacy, safety, and security. An example of such standards is an ISO certification process for life support robots available at testing labs above. As a step towards the successful international spread of domestically produced robots, Japan set out to establish a broad variety of new standards. Examples of these include a standard for a universal platform to serve as a foundation and a benchmark for inter-robot communication. As with any communication, the basis for exchange of information between two entities is a common language. Standardization is imperative for Japan, as robots assembled in Japan use locally produced hardware and software, a source of its competitive advantage, which can only be capitalized if the robots are capable of interaction with foreign infrastructure (Headquarters for Japan's Economic Revitalization, 2015).

An investment into changing, evolving, and developing the technology alone is not enough, however. The revolution must go together with a societal and educational change and Japan needs to adapt to this change. In a Growth Strategy proposal released by the Prime Minister's Office in 2017, this is referred to as "Society 5.0". It is characterized by an uninterrupted network of physical and digital world, connected using advanced technologies introduced in Industry 4.0 (Headquarters for Japan's Economic Revitalization, 2015).

The aims of the proposal are the following (Headquarters for Japan's Economic Revitalization, 2015):

- Reform healthcare industry by taking advantage of big data, internet and AI,
- Devise regulation on the use of autonomous vehicles for public and private transit, and parcel delivery,
- Adapt the financial industry to support open innovation and encourage a cashless economy.

In an environment where collaboration with advanced technology is not limited only to engineers and IT professionals, but also relevant for everyone else, cultural change is critical. The general public will familiarize itself with modern technology to some extent through work and life experience, but also in a structured manner through reskilling and a revised education system planned and assigned by the Japanese Ministry of Economy, Trade and Industry and the Ministry of Health, Labour and Welfare. Students will receive a basic understanding about robots at the first and second level of education as part of the adapted general curriculum. Genuine interaction and collaboration between robots and humans, which is the prerequisite to truly reap the benefits of such revolution, is only possible in a "robot barrier-free society" (Headquarters for Japan's Economic Revitalization, 2015). In such a society, robots and humans can co-exist and collaborate with each other regardless of age. Robots not only take over the repetitive and manual tasks, enabling people to focus and move to more meaningful and value-added activities, but also support them in other parts of their lives, including education, security, hygiene, agriculture, eldercare and perform other social duties (UNESCO, 2016).

Today, one in five of Japanese citizens is over 65 years old, the highest proportion in the world. By 2030, it is predicted that approximately 30 percent of people will fall in that same age category, and by 2040, it could increase by another 10 percent (Mullin, 2018). This makes Japan the second largest healthcare market in the world (Walsh, 2012) and can, as such, benefit significantly from digitalization and automation of the health sector. A surplus in demand for eldercare service combined with a projected major deficit in supply of eldercare providers has not gone unnoticed. Japanese government has set to tackle the estimated shortage of 380,000 nurses using state-of-the-art technology (Foster, 2018). An example of a successful implementation includes a virtual reality simulation of various known brain diseases, developed by a Tokyo-based operator of homes for elderly, Silverwood Corp. Their goal, supported by the Japanese Ministry of Health, Welfare and Labor, is to educate the families and visitors of their residents through first-person videos with an intent to realistically simulate the experience of everyday activities through the eyes of the sufferers (Otake, 2017). Aside from just empathizing, it also provides a crucial insight into their visual perception of situations and a deeper understanding of certain behaviour. Other examples include the use of robots in social settings, for exercising or even automated devices and suits that help workers in homes for elderly in physically picking up their patients. Security, information distribution and incident prevention are some other fields where Japan is utilizing the use of autonomous robots. Studies have shown that the interaction with robots is more successful using humanoids, i.e. robots designed to resemble humans or which take an appearance of a known popular character, and Narita International Airport, one of Japan's largest airports, is experimenting with such robots. They are capable of detecting and reporting potential violent behaviour, keep track of unattended items and perform routine tasks, such as greeting the visitors and providing directions. As a result of a partnership between Toyota Motor Corporation and the Tokyo Organising Committee, humanoids shall be entrusted similar roles at the coming Olympic Games in Tokyo, an opportunity to promote Japanese modernization and the benefits of coexistence between robots and humans (Greenspan, 2020). Society should welcome new technology with open arms and have value creation, usefulness, and global competitiveness at its core, to truly take advantage of the technological development (Headquarters for Japan's Economic Revitalization, 2015).

Aside from robotics, Japan is one of the leading economies with regards to the development and adoption of new technologies, including artificial intelligence, cloud computing and IoT. The Japanese government plays an important supportive role in this matter, which can also be seen in preferential tax treatment for mobile phone operators. The proposal, the role of which is to encourage investments in progressive technologies, modern communications infrastructure and encourages start-ups in information technology sector, includes a 15-percent tax credit granted to telecommunications companies that invest in researching, developing and enabling a future-proof communications infrastructure by adopting cutting-edge technologies, a prime example of which is the fifth-generation high-speed wireless network, or 5G ("LDP plans tax breaks," 2019; "Japan ruling bloc draws up tax reform plan," 2019).

Education in Japan is closely following the trends and new technology is embraced in many aspects of it. Textbooks are gradually becoming a thing of the past as they are available not only in a hard copy but can also be downloaded in an e-book format directly from school servers. Saving money on textbooks allows and encourages students to invest into a laptop or a tablet, which in higher education becomes a requirement (Logo Creative, 2019). A reform of Japanese education started in 2008 when University of Tokyo launched a Consortium for Renovating Education of the Future, an organization which actualizes education through a cooperation between universities, academic societies and industries (COREF, n.d.). One of their initiatives is an experimental classroom – a modern approach to teaching social skills which encourages creativity, teamwork and problem-solving. This is an attempt to step forward from conventional education, which is traditionally based on uniformity and memorization (Shirouzu, 2018). Fundamentals of technology are introduced to children very early. Smart Education, a Tokyo-based start-up developed an e-learning mobile app for kids targeted primarily at kindergartens and encourages children to draw and collaborate on simple tasks. Some of these tasks even introduce basic computer literacy, such as saving a picture after it is finished (Kageyama, 2018; Mori, 2014). Aiming to facilitate career advancement and increase job satisfaction, Education Reform Council of Cabinet secretariat is experimenting with the use of AI to evaluate skills and personal traits of an individual. Analysing this data allows a sophisticated model to identify their strengths and weaknesses and help in selecting ideal field of study and ultimately career (Tsuboya-Newell, 2019). Same principles could be utilized for job rotation and determining the most appropriate job position for an employee.

In 2019, Japan ranked 12th in the world in the Inclusive Internet Index. It placed 3rd in Asia, lagging only behind Singapore and South Korea, which constantly rank top 10 in the world and are a dominant force in usage and development of connected technologies (Inclusive Internet Index, n.d.). While its ranking was fairly consistent in all selected categories, it performed best in terms of internet availability, with 12th place among the 100 countries listed in the index, in part because of the significant technology adoption rate in Japan, both from the demand and supply point of view. With internet penetration among Japanese households at roughly 96 percent (International Telecommunication Union, 2018) and above average mobile and fixed broadband speed, not only in urban but also in rural areas, Japan is one of the leading economies in the world with regards to connectivity, digital and internet accessibility. The average fixed broadband internet speed in Japan is 103 Mbps, which puts it in 24th place globally with approximately 30 Mbps more than the global average. Their mobile speeds, however, fall behind (Ookla, 2020). With 33.49 Mbps it performs only marginally better than the global average and ranks 54th globally (Inclusive Internet Index, n.d.). Furthermore, the support and initiatives from the Japanese government and private sector to enable widespread availability of access to internet in public spaces is among the highest in the world as is the 3G and 4G network coverage despite having a relatively low number of Internet Exchange Points. According to Huawei Technologies (2019), Japan also achieved maximum points in mobile broadband subscriptions, IoT experience, and patents categories, reaching 9th place in the 2019 Global Connectivity Index.

Internet is used daily by as much as 91 percent of Japanese citizens, a large majority of whom access it both from both major platforms – from a computer and mobile device. This translates to a total of 118.6 million internet users, and puts it in 7th place globally (Clement, 2019).

4.5 Singapore

Unlike Japan, Singapore is a small economy, but it, too, already has one of the most automated manufacturing sectors in the world with 398 robots per 10,000 employees in 2016 (International Federation of Robotics, 2016). The country perceives manufacturing as one of the key pillars of its economy and is a leader in many areas, such as aerospace, semiconductors, chemicals, and biomedical sciences. According to Lai (2019), this is due to a lack of natural resources in the small island city-state, which has compelled the country to leverage technology to improve competitiveness and productivity. With about one quarter of jobs in the country at high risk of automation, the country has thus one of the lowest proportions of jobs under high risk (Lee, 2017). Furthermore, Singapore has adopted the National Robotics Program to further develop and drive robotics research and development and adoption. The programme is built around a whole-of-government approach, with coordination and participation of various government institutions (Kok Kiang, 2016). Part of the programme is the Singapore Smart Industry Readiness Index, launched in 2017 by the Economic Development Board. The Economic Development Board is a government agency under the auspices of the Ministry of Trade and Industry, responsible for strategies that enhance Singapore's position as a global centre for business, innovation, and talent (Economic Development Board, 2020).

The Singapore Smart Industry Readiness Index aims to provide a common framework for understanding Industry 4.0 in addition to evaluating companies' readiness levels. Specifically, its purpose is to equip companies with practical knowledge on the tangible benefits Industry 4.0 could yield, evaluate the maturity levels of their organisation and facilities and how the companies can improve in a targeted and incremental manner (Economic Development Board, 2017a). The core of the index draws on the Reference Architectural Model for Industry 4.0 and is comprised of three axes that represent different facets of company readiness, divided into eight key pillars: process, divided into operations, supply chain and product lifecycle; technology, divided into automation, connectivity and intelligence; and organisation, divided into talent readiness and structure & management (Economic Development Board, 2017b). The three axes or building blocks of the index were identified as the key fundamentals necessary to future-proof a facility, whereas the eight key pillars represent critical areas that require companies' focus to become future-ready according to the Reference Architectural Model for Industry 4.0.

The first axis, process, is essential for value maximisation. The Economic Development Board (2017a) states that under Industry 4.0, the concept of process improvements has expanded with increased focus on the integration of processes within the pillars of operations, supply chain and product lifecycle. Operations, the first pillar, is composed of planning and execution of processes which lead to goods and services production with the objective being to convert raw materials and labour into goods and services at the lowest possible cost. In the context of Industry 4.0, this objective remains intact but is enhanced with companies' newly found access to new technologies and approaches to achieve this goal more efficiently and quickly. This includes technologies such as data analytics, which can be used to reduce waste or improve inefficiencies; or wireless communications, which can be used to connect discreet processes and systems, enable remote monitoring and decentralised asset control (Economic Development Board, 2017a). The supply chain pillar encompasses the planning and management activities for raw materials and inventory within companies, from the point of origin to the point of consumption. Within the context of Industry 4.0, supply chains are becoming increasingly digitised with processes being increasingly connected through sensor networks and managed through central data hubs and analytics systems. Digitalised supply chains enable more holistic decision-making on cost, inventory, and operations, as well as greater speed due to reduced lead times and greater flexibility, personalisation as well as transparency (Economic Development Board, 2017a). The product lifecycle pillar focuses on the need for greater integration and digitalisation across different stages of product lifecycle management. The rapid evolution of digital tools and the ever-increasing volume of data being produced within organisations has enabled the creation of single information backbones that can be managed digitally. The concept of a digital twin, a virtual representation of physical assets, processes and systems involved in the product lifecycle, is important within Industry 4.0. Digital twins allow easy sharing of generated information, facilitating decision-making and enabling dynamic optimisation of processes. Another main benefit of digital twins is that the limitations of working with physical properties is removed. Multiple prototypes can be created and tested virtually and at a lower cost (Economic Development Board, 2017a).

The second axis of the Singapore Smart Industry Readiness Index is technology. In order to enable companies to realize their Industry 4.0 ambitions, a high degree of automation, pervasive connectivity and intelligent systems are necessary prerequisites. Therefore, the three pillars within the technology axis of the index are automation, connectivity, and intelligence. Automation was and continues to be a key enabler for companies to increase productivity. However, within Industry 4.0, its goals are changing from purely maximising efficiency to include other goals, such as the ability to quickly adapt to changing markets. The second pillar, connectivity, is an important characteristic of Industry 4.0 solutions. IoT-enabled devices, cloud computing and wireless infrastructure are enabling data collection and systems integration at a large scale. This also introduces vulnerabilities in company systems, the risk of which must be mitigated. Finally, the data produced by these new solutions and technologies has value, which companies can access through analysis and processing. The third pillar, intelligence, delivers this through machine learning and AI. Companies are in a better position to respond to changing external and internal business needs with the use of these tools, be it purposefully or autonomously (Economic Development Board, 2017a).

The third and final axis is the organisation. To ensure relevance amidst increasing competition under Industry 4.0, company organisational structures and processes should be adapted to ensure they keep pace. According to the Economic Development Board (2017a), two components will prove key to companies under Industry 4.0. The first is people and talent management, called the talent readiness pillar. Specifically, it is the ability of the workforce to drive and deliver on these initiatives that is crucial to company success. To achieve this, management must build systems and practices that will enable the workforce to stay competitive and capture new opportunities. On the other hand, the workforce must be multi-skilled and adaptable to manage dynamic and digitalised operations. The second pillar is structure and management. Structure refers to the system of explicit and implicit rules and policies that outline the assignment, control and coordination of roles and responsibilities, while management refers to enabling cooperation towards a well-defined common goal. Under Industry 4.0, greater decentralisation of decision-making, increased information openness and more collaboration will have to be underpinned by strong leadership, clear strategy and governance frameworks to ensure company success (Economic Development Board, 2017a).

To help companies in Singapore translate these concepts into practice, the Economic Development Board (2017a) advises companies to follow the LEAD principle (learn, evaluate, architect, deliver). Businesses in Singapore should understand key Industry 4.0 concepts thoroughly. The emphasis is for knowledge to not remain confined to the corporate management level but to reach the wider workforce. Furthermore, a common language among various stakeholders is imperative for successful Industry 4.0 transformation. The subsequent step for companies is to evaluate their current state and Industry 4.0 readiness level in accordance with the assessment tool. The third step is to architect a comprehensive transformation strategy and implementation roadmap. In this step, the index serves both as a checklist for companies, as well as a step-by-step improvement guide, breaking down intermediate steps of long-term transformations according to Industry 4.0 principles. Finally, companies should deliver impact and sustain transformation initiatives developed on the basis of the provided index (Economic Development Board, 2017a).

Between 2016 and 2019, Singapore planned to spend more than 450 million Singapore dollars on supporting robotics. The aims of the programme are to develop a globally competitive robotics industry, exploit advances in robotics to enhance the productivity and competitiveness of its manufacturing sectors and to support adoption of robotics to address local needs. An important element of this programme is ensuring that the adoption and benefits of robotics also reach SMEs, which are much less likely to opt for advanced robotic equipment (Government of Singapore, 2016).

4.6 Slovenia

In terms of digital economy, Slovenia is in the middle of the pack among European Union countries according to the Digital Economy and Society Index 2019 (European Commission, 2019f), ranking 16th out of 28 member states. The best performance is achieved in e-government, while the worst was in the use of internet services. In the first dimension, Connectivity, the country's ranking was 17th. It ranks best in fixed broadband take-up, where it placed 5th with 85 percent of households. It also performs well in terms of ultrafast (100 Mbps and above) broadband coverage, which is 20 percentage points better than the European Union average (80 percent in Slovenia versus 60 percent in the EU). On the other hand, ultrafast broadband take-up is much lower at 16 percent, partially due to a fast increase in the coverage of ultrafast broadband and partially due to broadband prices. The cost of broadband is a sore point for Slovenia, as it ranks 25th in the European Union in terms of affordability. Delays are also present in the framework for the adoption of 5G networks, where the necessary regulation is yet to be adopted (European Commission, 2019f).

In the Human capital dimension, the country is again in the middle of the pack, ranking 15th. While the country managed to improve its performance significantly up until 2017, its score has stagnated since then. Its best score in this dimension remains the share of ICT specialists in the total workforce at 3.8 percent, 12th place among European Union nations. However, this share has not improved significantly in the past two years. Worryingly, the share of ICT graduates in total graduates has fallen on a yearly basis from 4.1 percent in 2017 to 3.5 percent in 2019. The skills of the general population have not improved markedly either, with the share of individuals with at least basic digital skills remaining at 54 percent in 2017-2019, the share of individuals with above basic digital skills increasing only slightly from 28 percent in 2017 to 30 percent in 2019 and the share of individuals with at least basic software skills remaining at 57 percent throughout the 2017-2019 period. A matter of concern is also the fact that Slovenia used to be an early adopter of introducing ICT skills in school curricula, however it has not progressed in recent years. Computer skills are mandatory subjects in secondary schools, optional subjects in primary schools, while they are not taught at all in non-ICT vocational schools (European Commission, 2019f).

The use of internet services is the dimension where Slovenia posts the worst results compared to other European Union member states. In 2019, it ranked 21st in the Digital Economy and Society Index. While the share of people who have never used the internet declined to 16 percent in 2019, it was still 5 percentage points higher than the European Union average at the time. On the other hand, Slovenes consume more news online than their European counterparts at 77 percent of all internet users compared to the European Union average of 72 percent and are 50 percent more likely to use online courses than their European counterparts (14 percent versus 9 percent). However, the share of professional social network users (for example LinkedIn) among Slovene internet users is among the lowest in the European Union, with only 9 percent of users being part a professional social network. While these shares have mostly improved in the 2017-2019 period, some have improved more than others. The share of online shoppers has jumped 10 percentage points from 53 percent in 2017 to 63 percent in 2019, a similar jump occurred in the share of social network users. On the other hand, online consultations and voting, professional social network and video on demand have stagnated in the 2017-2019 period (European Commission, 2019f).

In the Integration of digital technology dimension, which measures the usage of electronic tools by businesses, Slovenia is again average, ranking 15th out of 28 European Union member states. The country has an above-average share of SMEs selling online cross-border (6th in the European Union), likely because the country's domestic market is small. The country performs best in enterprise cloud usage, with 17 percent of enterprises using cloud solutions, ranking 11th in the European Union. The country is committed to the advancement of new digital technologies and to investing in digital technologies through European Union programmes. There is a large sectoral difference in terms of digital integration, with some sectors experiencing much higher degrees of digital integration uptake than others. The automotive sector has one of the highest degrees of digital integration, likely due to foreign principals and adequate capital. Slovenia also has successful start-ups in the ICT sector, which are mainly active in some niche services, such as blockchain, development of business applications, cybersecurity, measurement equipment and online advertising. In order to accelerate the economy's digital transformation, improving access to finance and addressing the shortage of skilled ICT workers is crucial (European Commission, 2019f).

Slovenia achieves the best results in the Digital public services dimension, ranking 14th among European Union countries. While the share of e-government users is not particularly high at 56 percent compared to 64 percent in the European Union, a wide range of online services for businesses is available. In terms of usage of e-health services by individuals, the country ranks 6th with 27 percent of Slovenes having used health and care services provided online, with the use of electronic prescriptions being almost ubiquitous at 98 percent, ranking third in the European Union. Overall, the take-up of digital public services is the most worrying, as there is a serious divergence compared to other sectors. For example, 90 percent of people that hold e-signature certificates use them for online banking services, 60 percent for doing taxes online and only 20 percent for e-government services. The likely reasons for this are a lack of a widely used and easy-to-use national electronic identification means, low awareness of the availability of e-government services and procedure complexity. On the other hand, Slovenia continues to be a champion of the open availability of public sector data, with a high level of transparency of the public administration, ranking 7th in the European Union, which benefits press and citizen oversight of public affairs and spending (European Commission, 2019f).

Much like digital integration, robotization in Slovenia has progressed the most in the automotive industry. This is in accordance with the global trends, as the automotive industry as a whole amounts for more than 30 percent of all international sales of industrial robots and grew by 20 percent in 2018. And even though China represents nearly 36 percent of global industrial robot sales, it still only represents 97 robots per 10,000 workers. In the case of Slovenia, this ratio is, surprisingly, higher. There was a total of more than 1000 industrial robots in use in Slovenia in 2017, which amounts to 144 robots supporting every 10,000 workers, or approximately 49 percent more than in China and well above the European average of 106 per 10,000 workers. Germany, however, employs more than twice as many robots per capita. The two countries with the highest margin, South Korea and Singapore, lead with 710 and 658 robots per 10,000 workers, respectively (International Federation of Robotics, 2016).

While its involvement in the existing robotics industry is low (Lenarčič in Koman et al., 2017), in 2015 the Government of Slovenia adopted a new strategy targeting the manufacturing sector, the Smart Specialization Strategy (hereinafter: S4) (Čeh, 2015; Government of Slovenia, 2015). As Slovenia is a small economy, it is difficult for its companies to be market leaders. However, there is an opportunity to capture and be highly competitive in niche markets, compared to mainstream markets where there is a presence of larger and better funded competitors. This is addressed by smart specialization, which represents an opportunity to focus research and development investments into areas where Slovenia holds a critical mass of knowledge, capacity and competences and which hold innovation potential for market positioning globally. The strategy's aim is to improve the competitiveness of the economy of Slovenia by strengthening its innovation capacity, fostering structural transformation, diversifying existing industries and services and develop new fast-growing companies in emerging industries and fields. According to the Government Office for Development and European Cohesion Policy (2019), the Smart Specialization Strategy has three goals:

1. increasing value added per employee,
2. improving the competitiveness of the Slovenian economy on global markets by increasing the share of knowledge and technology-driven exports
3. increasing entrepreneurial activity in the country.

With the Smart Specialization Strategy, the government defined strategic development priorities and identified potential niches, which are supported by targeted, holistic and adaptable measures. These priorities were not defined in a top-down approach but were developed according to a quadruple helix development model in partnership with business, knowledge institutions, other stakeholders and the government. According to the Government Office for Development and European Cohesion Policy (2019), the strategy defines three priority pillars and nine focus area and technologies:

1. Digital pillar
   a) Smart cities
   b) Smart buildings
2. Circular pillar
   a) Circular economy transition
   b) Sustainable food
   c) Sustainable tourism
3. Industry 4.0 pillar
   a) Smart factories
   b) Health and medicine
   c) Mobility
   d) Materials

The Smart Specialization Strategy also forms the basis for a new national model of research and development cooperation between key innovation stakeholders, which promises to enable better integration and cooperation with European and international research and innovation networks, platforms and consortia. The government views this research and development internationalisation as a key to success, along with market diversification. Systemic integration into Europe-level initiatives represents a significant opportunity for future successful cooperation with leading companies and research institutions in Europe and the world. The implementation of the strategy is also supported through national and European Union funding of about 980 million euro for the 2016-2020 period, 50 percent of which is earmarked for research and development and innovation projects, 13 percent for development of human resources and 37 percent for entrepreneurship and internationalisation (Government Office for Development and European Cohesion Policy, 2019).

This new model of research and development cooperation is centred around Strategic research and innovation partnerships (hereinafter: SRIP), long-term partnerships between companies, research institutions, the government, local communities, non-governmental organisations and other stakeholders. In 2016, SRIPs were established for each of the nine focus areas of the Smart Specialization Strategy. SRIPs collaborate and coordinate with the government to develop policy for each focus area as well as organise a comprehensive research and innovation ecosystem for their respective focus area. The aim of SRIPs is to pool the investment and intellectual potential of stakeholders and help them set up a comprehensive innovation ecosystem, enabling them to successfully enter and compete on global markets and improve their market position in priority areas (European Commission, 2019f). In practice, this takes the form of creating and enhancing existing value chains, coordinating more complex joint research and development projects, enabling access to international research and innovation platforms as well as facilitating access to suppliers and organising common marketing and promotional activities. It is envisioned that these partnerships would allow member companies to also perform planning of future labour and competence needs (Government Office for Development and European Cohesion Policy, 2019).

The activities of strategic research and innovation partnerships are defined based on action plans that are composed of the following (Government Office for Development and European Cohesion Policy, 2019):

- A concretisation of focus areas and technologies with defined goals that include a definition of comparative advantages of Slovenia in the identified focus area based on global trends, value chains and competition and goal-associated key performance indicators.
- A common research activity plan that includes the definition of comparative advantages of the SRIP and/or its members and the definition of competences and capacities of SRIP members throughout the development cycle.
- An internationalisation plan that includes both the internationalisation of marketing activities as well as the internationalisation of research activities.
- A human resource development plan that includes a forecast of future competency needs and a concretization of training and retraining needs as well as requirements for workforce skills and the necessary education curriculum adjustments.
- An entrepreneurship promotion plan.
- Proposals to improve and optimise existing regulatory frameworks.

As of 2019, the nine strategic research and innovation partnerships had a total of 783 members, 81 percent (633 members) of which are companies, a further 60 percent of those are micro and small enterprises, 18 percent are medium-sized enterprises, whereas 22 percent are large companies (Government Office for Development and European Cohesion Policy, 2019). Knowledge and research institutions represent 11 percent of all members with 89 members in total. According to the Government Office for Development and European Cohesion Policy (2019), virtually all key Slovenian research organisations and universities are members of SRIPs.

The Digital Innovation Hub Slovenia is a project that has come out of the SRIP framework. The purpose of the project is to provide a one stop shop for digital transformation, creating awareness and providing services to companies and other organisations in Slovenia. Its key initial partners include existing partners from several SRIPs, industry representatives, universities, the Chamber of Commerce and Industry of Slovenia, the Ljubljana Technology

Park and the FabLab network, the national network of creative laboratories (European Commission, 2019f).

In 2019, the Government of Slovenia began preparing a new industrial strategy to address the growing challenges of environmental sustainability and its impact on industry, as well as the competitiveness of the country's industries in light of growing robotization and automation. The aim of the new industrial strategy is to foster green technologies, creative industries, "smart" industries and inclusive development through a consensus of major stakeholders (Petrov, 2019).

In 2017, the government introduced new measures to attract greenfield investments by increasing financial support and facilitating planning processes (Tomažič & Smrekar, 2017). One notable investment to result from this new program is the development of the Slovenian unit of the Japanese industrial robot manufacturer Yaskawa in the southern town of Kočevje (Čater, Jakšič, Groznik, Lavrič & Skubic, 2017). A new 25 million-euro manufacturing unit opened in April 2019, with a further expansion announced in November 2019 with plans to expand capacity to assemble up to 5000 robots annually by 2023, becoming one of the European hubs of the corporation (Bertoncelj, 2019).

Furthermore, Slovenia also aims to be at the forefront of artificial intelligence development with the International Research Centre on Artificial Intelligence, a pioneering institution established by the Government of Slovenia in 2020 as part of the Jožef Stefan Institute, the largest research institute in the country. The research centre will operate under the auspices of the United Nations Educational, Scientific and Cultural Organisation (hereinafter: UNESCO) (Črnko, 2020). The aim of the research centre is to provide a coordination point, funding route and exploitation accelerator for approaches to achieving the United Nations Sustainable Development Goals that make use of artificial intelligence, while its objectives are research, advocacy, capacity-building and dissemination of information about artificial intelligence (Jožef Stefan Institute, n.d.).

Based on the findings presented in this chapter, we find that comprehensive strategies are more successful at addressing the impacts of the Fourth Industrial Revolution than individual responses. The Fourth Industrial Revolution has various policy implications for governments, reaching beyond the particular sectors of the economy that might be directly affected and this impact promises to increase further with advances in automation, artificial intelligence and other technologies and their continuing widespread adoption. Autonomous vehicles might, for example, directly impact the automotive and logistical industries, but their effects would be far-reaching beyond the two industries, affecting various facet of the economy and society. The spread of robots beyond industrial settings is another such example. Countries with comprehensive strategies will continue to be better equipped to deal with these multifaceted and complex issues as technological development progresses.

Furthermore, we also find that Slovenia does indeed require to adjust its current policies to successfully tackle the Fourth Industrial Revolution. It is clear from the findings that the country, while attempting to set in place policies that will enable the economy to benefit from the effects of the Fourth Industrial Revolution, the current strategy predominantly addresses the manufacturing sector, failing to pursue a more holistic approach that would take into account the wider implications of pervasive automation and robotization, as well as other impacts of the Fourth Industrial Revolution on the rest of the economy and society at large.

CONCLUSION

The Fourth Industrial Revolution promises to provide a boost to productivity around the world. Yet not all countries will benefit equally – the regulatory framework will prove important yet again when harnessing the opportunities of technological advances.

We posed six research questions, which were explored throughout this paper. We summarize our findings as follows:

1. The Fourth Industrial Revolution will increase overall productivity. The benefits of automation, robotization and other drivers of the Fourth Industrial Revolution will likely have differing effects across regions and industries, but their overall contribution to productivity will be positive.
2. The Fourth Industrial Revolution will have divergent effects on job demand. While most jobs contain tasks that are automatable, some jobs are more automatable than others, leading to diverging demand for jobs. Some jobs may be made obsolete in the coming years, while many will change as some tasks are automated away. Finally, many new previously inexistent job profiles will be created.
3. Educational systems will be affected by the Fourth Industrial Revolution. The effects on labour demand and the subsequent changes in the labour market will provide a strong impetus to adapt educational systems to new needs as well as enable worker reskilling to prevent negative economic and societal consequences.
4. The Fourth Industrial Revolution will increase the importance of digital security. The increasing proliferation and reliance on digital and automated technologies, which will be connected to the Internet, will push companies and governments to place greater value on digital security.
5. Comprehensive strategies are more successful at addressing the impacts of the Fourth Industrial Revolution than individual responses. The effects of new innovations and technologies brought about by the revolution are multifaceted and complex, so the policy responses must be varied and consider all externalities as well.
6. Slovenia should adjust its current policies to successfully tackle the Fourth Industrial Revolution. While the country is attempting to adopt policies that will enable the

economy to benefit from the revolution, only certain aspects and sectors are being covered. A more holistic approach, taking into account the wider effects of increasing automation and robotization on society, would be more beneficial.

The labour market implications will probably be the most disruptive, with economic and social repercussions, especially on inequality and regional development. Governments have the ability to both benefit from the positive effects and mitigate the negative effects with the right policies in place. An efficient bureaucracy, facilitated trade and knowledge exchange, access to human capital, framework improvements for automated machines, investments in next-generation infrastructure on one side, and investments in education and reskilling, as well as effective redistribution on the other, should allow countries to successfully transition to the new development paradigm.

The increasing presence of robots in national economies has led to a divergent set of policies, organically developed in different countries based on their specific economic, social and other factors. However, one of the overarching themes has been the government's active role in further developing robotics and harnessing its benefits to the economy and society to the maximum effect. This is an important consideration – currently, government involvement in the robotics industry in Slovenia is low. However, if the country wishes to harness robotics in order to tackle some of its upcoming challenges, such as an aging society or transition to a high-income society, this will have to change.

Furthermore, in order to better serve society and the economy, robot usage should spread to other industries and into wider society. The government has adopted the Smart Specialization Strategy (S4) in 2015, however, its scope is limited to the manufacturing sector. While S4 does aim to increase robot density among non-automotive industries in the manufacturing sector, Japan and Denmark's leads should be followed by aiming to spread robots into areas where they can improve the quality of life, not just productivity (healthcare, elderly care, etc.). The government began work on a new industrial strategy in 2019, however the implications of automation, robotics and AI on wider society remain unaddressed. While robots can help recover lost economic growth as society ages, they can also effectively serve the increasingly large elderly population. Furthermore, in terms of industry, special care should be given to SMEs, which are slower in adopting robotics technology.

Many of the analysed countries have, like Slovenia, began the process of robotization from the bottom up, with an initial impetus from businesses or a combination of business and research institutions. This has led to the development of robotics clusters in Denmark and Austria, but not in Slovenia. It is difficult to build a cluster out of scratch. The driving force behind robot adoption is currently large companies, often a part of multinational companies with their own R&D capabilities. A precondition for a successful cluster formation is that there is a basic desire to cooperate among existing businesses and institutions. If the benefits of working together outweigh the costs of going on their own, companies should be encouraged by the government to cooperate further. The government can help by facilitating deeper ties between companies, research institutions and universities. SRIPs are one such example, which holds promise for the future. This is important from the perspective of labour as well. Improved relationships between business, education and research can help shape educational programmes, address the skills gap and thus ensure a better fit between the skillset of entrants to the labour market and the required skills from companies. A greater focus on robotics and the inclusion of robot-related topics into other fields of study will help educate a new generation of Industry 4.0 workers.

The planning and implementation stages of future policy should also transparently address societal perceptions and concerns, especially with regards to safety and privacy. This is an important consideration: while current personal data legislation in the EU can be considered as an obstacle to developing new advanced analytics-based solutions, most EU residents do not support data sharing among companies without their permission, even when it helps companies to improve their services.

Lastly, it is important to emphasize good practices. Despite the natural tendency of companies to group together geographically, it is possible to achieve more balanced regional development. Yaskawa's Kočevje investment is a case in point. Slovenia is a small country with short distances. This enables less developed regions to compete on a more equal footing with the help of government policy.

Slovenia has an opportunity to obtain a sustained competitive advantage through robotics by being an avid early adopter and focus on the development of its own robotics cluster. It has the potential to become a robotics champion and leader in the surrounding region. The cooperation and collaboration of industry, government, the scientific community, and educational institutions may prove crucial in ensuring that the country fulfils its potential and that robotization turns out to be a success for its economy and its citizens.

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APPENDIXES

Appendix 1: Povzetek (Summary in Slovene language)

V nalogi raziščeva implikacije četrte industrijske revolucije na gospodarstvo in družbo in kako se Slovenija sooča z izzivi četrte industrijske revolucije skozi politike. Četrta industrijska revolucija je pojav, ki izhaja iz hitrega tehnološkega razvoja, ki ima potencial omogočiti preboje v učinkovitosti in produktivnosti gospodarstev in posledično njihovi globalni konkurenčnosti in s tem preobraziti tako gospodarstvo kot družbo. Pojav bo imel večplastne učinke na različne sektorje gospodarstva in različne dele družbe, pri čemer bodo učinki mešani, tj. tako pozitivni kot negativni. Za oblikovalce politik in odločevalce je pametna zasnova ukrepov bistvenega pomena, da se maksimira pozitivne učinke in učinkovito ublaži negativne učinke.

V nalogi opredeliva gonila četrte industrijske revolucije in jih razdeliva na tri kategorije: digitalne, fizične in biološke. Sočasna uporaba novodobnih tehnologij bo postopoma vedno bolj zabrisala meje med biološkim, digitalnim in fizičnim svetom, posledice česar so vidne v vsakdanjem življenju že danes. Medtem ko je bilo glavno gonilo tretje industrijske revolucije fizično, so v času četrte industrijske revolucije prevladujoči predvsem digitalni dejavniki, med katere sodijo umetna inteligenca, internet stvari in robotizacija. Povezovanje naprav v skupno omrežje omogoča nov način medsebojnega komuniciranje, ki ga do zdaj nismo poznali, in sicer komuniciranje med napravami samimi. Napredek pa se ne kaže le na neživem področju, temveč tudi na področju živih bitij. Eno pomembnejših bioloških gonil, CRISPR, omogoča manipulacijo zaporedja DNK, s čimer je mogoče vplivati na boljši pridelek, ozdraviti genetske bolezni pri živalih ali celo vplivati na izgled in sposobnost ljudi.

Industrija 4.0 je bila ena izmed prvih večjih iniciativ, ki so poskušale zaobjeti učinke četrte industrijske revolucije na globalne vrednostne verige. Osnovni princip Industrije 4.0 je izkoriščanje tehnoloških inovacij in z njimi povezanih pojavov, kot so široka dostopnost in uporaba zanesljivih in cenovno ugodnih internetnih povezav in interneta stvari, integracija tehničnih in poslovnih procesov v podjetjih, povezava poslovnih procesov preko meja podjetij, digitalno mapiranje in virtualizacija resničnosti ter pametne tovarne s pametnimi proizvodnimi sredstvi in pametnimi proizvodi.

V nadaljevanju preučiva učinke četrte industrijske revolucije na štiri identificirana področja in morebitne potrebne odzive na te učinke, in sicer na področju produktivnosti, trga dela, izobraževanja in digitalne varnosti. Poleg teh štirih področij omeniva učinke še na nekatera druga omembe vredna področja, kot so dohodkovna neenakost, regionalni razvoj in zdravstvo.

Čeprav je povečanje produktivnosti nepogrešljiv člen industrijskih revolucij, se razviti svet trenutno sooča z upočasnitvijo rasti produktivnosti dela. Kljub temu dejstvu pa imajo posamezni pojavi, ki sestavljajo četrto industrijsko revolucijo, kot so mdr. avtomatizacija, robotizacija in avtonomna vozila, pozitivni učinek na produktivnost gospodarstva. Ker ti pojavi vplivajo tudi na sektorsko strukturo gospodarstva, je aktivno odzivanje s strani držav bistvenega pomena, da se olajša prestrukturiranje podjetij.

Spremembe, ki jih prinaša nova inovativna tehnologija, pa ne vplivajo le na produktivnost, temveč korenito posegajo tudi v trg dela. V tem trenutku še ni moč kvantitativno oceniti, kolikšen bo učinek teh sprememb, saj so si mnenja strokovnjakov nasprotujoča. Nekateri strokovnjaki trdijo, da bodo robotizacija, umetna inteligenca in avtomatizacija vodili v izgubo večjega deleža delovnih mest, saj bodo v mnogih vlogah roboti v celoti nadomestili delavce. Na drugi strani pa avtorji menijo, da je potencial avtomatizacije precenjen. Trdijo, da je popolna avtomatizacija mogoča le v primeru nekaterih nalog in ne celotnega dela. Delna avtomatizacija je mogoča pri skoraj vsakem delovnem mestu, stopnja potenciala avtomatizacije pa je odvisna od narave dela samega. Le-ta je višja pri delovnih mestih, ki vključujejo večji delež fizičnega dela ter pri rutinskem delu. Potencial avtomatizacije pa ne variira le med panogami, temveč tudi med državami. Kljub različnim mnenjem se obe strani strinjata, da tehnološki napredek od nekdaj uničuje nekatera delovna mesta ter hkrati ustvarja povsem nova, ki jih danes še niti ne poznamo.

Vpliv četrte industrijske revolucije na trg dela je korenito povezan z izobraževanjem. Po nekaterih ocenah bo do 60 odstotkov tistih, ki se izobražujejo danes, zaposlenih na delovnem mestu, ki ga danes še ne poznamo. Razmak med pričakovanim znanjem s strani delodajalcev in dejanskim znanjem prosilcev za zaposlitev je vedno večji, kar vodi v nezaposljivost izobraženih kadrov in neuspešnost podjetij pri iskanju zadovoljivo pripravljenih delavcev. S tem je povezan tudi izziv neusklajenosti znanja, saj se hkrati pojavlja prenasičenost nekaterih kadrov, kot na primer za delo v administraciji, in pomanjkanje kadrov na področju informacijskih tehnologij. Prav zato je ključnega pomena, da se gospodarske spremembe odražajo tudi v učnih načrtih, saj mora izobraževalni sistem stopiti v korak s časom in zagotoviti, da učenci zapustijo ustanove s pridobljenim znanjem, ki zadostuje potrebam podjetij na trgu. To je najlažje zagotoviti skozi tesnejše sodelovanje med izobraževalnimi ustanovami in podjetji. Poudarek pri izobraževanju pa mora biti tudi na t. i. mehkih veščinah, saj le-te ločijo ljudi od robotov in nam proti njim nudijo konkurenčno prednost. Med te veščine na primer sodijo kreativnost, komunikativnost, empatija in sposobnost vodenja in ekipnega dela.

Četrta industrijska revolucija bo imela vpliv tudi na področje, ki do nedavnega ni bilo v središču pozornosti strokovne in širše javnosti, vendar postaja vse pomembnejša tema. S povečanjem digitalizacije in avtomatizacije gospodarstva se odločevalci vse pogosteje srečujejo s potrebo po zagotavljanju digitalne varnosti. Današnja medsebojna odvisnost in hitro povečevanje uporabe interneta stvari in pametnih tovarn ter prihajajoče tehnologije, kot so avtonomna vozila, bodo zahtevale nove rešitve in nove pristope do zagotavljanja varnosti in bodo sprožile tudi nove etične in filozofske dileme, na katere bodo odločevalci morali odgovoriti.

Vpliv inovacij in tehnologij kot praktični primer raziščeva tudi na konkretnem področju, in sicer na t. i. »zadnjem metru dostave«, in ga ovrednotiva na področju produktivnosti, trga dela, izobraževanja in digitalne varnosti. Termin »zadnji meter dostave« se navezuje na zadnji del logistične verige, kjer dostavljavec dostavi pošiljko naslovniku. Izziv, da naslovniki v času dostave v večji meri niso prisotni, je poskusilo rešiti mnogo zagonskih kot tudi večjih podjetij. Med bolj razširjene rešitve sodijo brezpilotni letalniki, paketomati in avtonomna dostavna vozila. Medtem ko omenjene rešitve v večji meri vse pripomorejo k produktivnosti logističnih podjetij, se z vidika vpliva na digitalno varnost, izobraževanje in trg dela med seboj razlikujejo.

V okviru presoje politik kot odziv na izzive četrte industrijske revolucije analizirava pristope v petih državah, in sicer na Danskem, v Nemčiji, Avstriji, na Japonskem ter v Singapurju. Vse analizirane države imajo razvita mednarodno vpeta gospodarstva. Danska je dom močnega grozda robotike, ki se je razvil z organsko rastjo in ciljano pomočjo države. Danska je začela s pripravo ukrepov na podlagi celovite strategije o prihodnosti danskega gospodarstva. Ukrepi se osredotočajo na izboljšanje izobraževalnega sistema, da se zviša stopnja znanja ljudi z nižjimi stopnjami izobrazbe ter poveča poudarek na ustvarjalnosti in kritičnemu mišljenju na univerzitetni stopnji. Ukrepi so predvideni tudi na področju konkurenčnosti podjetij, na področju trga dela, kjer je poudarek na vseživljenjskem učenju in prekvalifikaciji delavcev ter na povečanju internacionalizacije gospodarstva. Nemčija je bila z iniciativo Industrija 4.0 med prvimi državami, ki so se začele sistematično odzivati na četrto industrijsko revolucijo, vendar ima pristop do robotizacije drugačen kot Danska, in sicer je veliko bolj dirigiran od zgoraj navzdol. Posledično se država ukvarja s problemom, kako digitalizirati in modernizirati pomemben sektor srednje velikih in malih podjetij, t. i. »Mittelstand«. Avstrija ima podobno stopnjo digitalizacije kot Nemčija, pri čemer je država že zgodaj osnovala podrobno strategijo soočanja z izzivi umetne inteligence. Japonska je vodilna država na področju robotike. Za državo je značilna stalna podpora države in širši pogled na vplive četrte industrijske revolucije, ne samo na gospodarstvo, temveč na celotno družbo, pri čemer pomembno vlogo igrajo rešitve, kot so roboti pomočniki, ki naj bi predvsem pomagali pri velikem deležu starostnikov v družbi. Singapur je v veliki meri povzel nemški pristop do robotizacije in ga obogatil s kooperativnim pristopom med različnimi javnimi agencijami in pri tem doživel veliko mero uspeha, saj je med državami z najvišjo stopnjo gostote robotov. Razvito je bilo tudi orodje, s pomočjo katerega lahko podjetje presodijo svojo stopnjo pripravljenosti na četrto industrijsko revolucijo in hitro identificirajo možne izboljšave.

Vse večja prisotnost robotov in avtomatizacije v gospodarstvih je privedla do različnih odzivov, ki so se razvili na podlagi potreb posameznih držav in glede na specifične ekonomske, socialne in druge faktorje. Aktivna vloga države je glavno vodilo vseh teh različnih pristopov. V Sloveniji se je do sedaj država ukvarjala predvsem z implementacijo inovativnih rešitev v posamezne panoge s pomočjo SRIP-ov in strategije pametne specializacije, ki pa se omejuje na industrijski sektor in ne nagovarja celotnega gospodarstva, niti širše družbe, avtomatizacija pa se je v največji meri pojavila v avtomobilski industriji. Slovensko gospodarstvo ima z vzpostavitvijo in implementacijo celovite strategije odzivov na četrto industrijsko revolucijo ter z aktivno podporo nastajajočemu grozdu robotike in nastajajočim UNESCO centrom za umetno inteligenco priložnost pridobiti trajno konkurenčno prednost na svetovnih trgih.

Appendix 2: Transcript of interview with Tadej Visinski (in Slovene)

1. Please describe your company. What does Direct4me do?
   Prosim opišite dejavnost vašega podjetja. S čim se ukvarja Direct4me?

Direct4.me je ameriško podjetje (Palo Alto, CA), za katerega drži podjetje Kivi Com d.o.o. licenco za opravljanje storitev v jugovzhodni Evropi. Direct4.me rešuje t.i. problematiko dostave zadnjega metra s povezovanjem spletnih trgovcev, logističnih podjetij, upravnikov stavb ter drugih storitvenih podjetij, z namenom, da uporabniku ponudijo brezskrbno prevzemanje in vračanje pošiljk. To je omogočeno z uporabo pametnih paketnih paketnikov, ki delujejo brez interneta in električne napeljave, ter jih je mogoče odpreti s katerim koli mobilnim telefonom.

2. What is the last yard delivery problem?
   Kaj je problematika zadnjega metra dostave?

Zadnji meter dostave se nanaša na najkrajši del verige blagovne dostave, od dostavnega vozila do naslovnikovih vrat. Čeprav je razdalja same dostave najkrajša, pa je paradoks v tem, da je hkrati najdražji del dostave. Pošiljke je namreč, za razliko od dostave do skladišč, potrebno dostaviti na posamične naslove, kar pa še otežuje dejstvo, da je predpogoj za uspešno dostavljeno pošiljko ta, da ga na drugi strani prevzame naslovnik. Dostava pošiljk pa je običajno v dopoldanskem času, ko je večina naslovnikov v službi.

3. What is your role in this company?
   Kakšna je vaša vloga v tem podjetju?

V podjetju Kivi Com d.o.o. sem zaposlen kot direktor podjetja ter trenutno primarno opravljam vlogo vodje vzpostavitve mreže Direct4.me pametnih predalčnikov v Sloveniji ter v širši regiji.

4. Would you describe your company as innovative? If yes, how? Please give an example.
   Ali bi opisali vaše podjetje kot inovativno? Če da, kako? Prosim, podajte primer.

Da. S projektom Direct4.me smo pionirji na področju domačih pametnih paketnikov na območju Republike Slovenije, skupaj s partnerskim podjetjem pa smo eden od vodilnih igralcev na trgu mobilnih transakcij, prenosu informacij in vrednosti z uporabo zvočnega kanala (t.i. Data-over-Voice tehnologija).

5. Which modern technological tools does your business use in its day-to-day operations? Why?
   Katera moderna tehnološka orodja implementirate v svoje poslovanje oz. produkte? Zakaj?

Kot večina sorodnih podjetij, uporabljamo vsa klasična orodja, na primer tista, v okviru Microsoft Office paketa, katera pa smo pred časom tudi povezali v Enterprise paket. V okviru tega sedaj koristimo na primer rešitev za shranjevanje in deljenje datotek v oblaku, Microsoft SharePoint, ter program za komuniciranje in povezovanje med sodelavci in ekipami, Microsoft Teams.

Za planiranje nalog in vodenje uporabljamo sistemsko orodje za agilno projektno vodenje, Jira. S tem smo občutno izboljšali prakso poteka informacij in odgovornosti ter pospešili postopek in uspešnost pri razvoju novih produktov in pri skrbi za obstoječe.

6. How does the implementation of new modern technologies affect your company's operations and existing processes? *Kako implementiranje novih modernih tehnologij vpliva na poslovanje podjetja in ustaljene procese v podjetju?*

Prehod iz poljubnega števila komunikacijskih kanalov v enoten sistem v okviru Microsoft 365 Enterprise ni bil pretirano dramatičen, je pa vseeno imel posreden in neposreden vpliv na vse zaposlene kot tudi zunanje sodelavce in na koncu koncev tudi stranke. Za karseda mehek prehod je skrbel naš interni sistemski administrator, ki se je s tem namenom najprej udeležil izobraževanja na temo vpeljave in uporabe tovrstnega orodja, nato pa vodil tudi interno delavnico za vse zaposlene v podjetju.

Uvedba orodja Microsoft Teams je nadomestila vrsto drugih komunikacijskih kanalov, ki smo jih pred tem uporabljali hkrati, kar je pogosto vodilo do zmede in izgubljenih informacij. Poleg boljšega pretoka informacij se je kot ključna prednost izkazalo tudi enotno mesto za hranjenje datotek, saj so nam tako vsem vedno na voljo in se ne dogaja, da je neka datoteka shranjena lokalno na računalniku, ki fizično ni prisoten na lokaciji.

6.1. Did the implementation take a lot of time?
Je vpeljava teh orodij vzela dosti časa?

Vpeljava Office 365 projekta je bila približno kot pričakovano. Bolj zahtevna in časovno intenzivna, predvsem pa tudi bolj postopna, je bila vzpostavitev sistema za vodenje projektov Jira. Ker v okviru podjetja nismo imeli nobenega strokovnjaka na tem področju, smo skupaj s partnerskim podjetjem zaposlili osebo, katere vloga v podjetju je omejena izključno na vzpostavitev in kasneje skrb za sistem Jira. Na to delovno mesto smo zaposlili posameznika, ki je imel predhodne izkušnje z vpeljavo tovrstnega sistema pri sorodnem tehnološkem podjetju.

6.2. Do you notice any benefits as a result of it?
Ali že opažate kakšne pozitivne posledice implementacije?

Za enkrat še ni mogoče količinsko ali finančno opredeliti prednosti vpeljave sistema Jira, predvidevamo pa, da bo sinergija v kombinaciji z Microsoftovim orodjem doprinesla predvsem na podatkovnem, vodstvenem in koordinacijskem področju. Odzivi zaposlenih so večinoma pozitivni.

7. How does your product affect different users and/or the economy? *Kako vaš produkt vpliva na različne uporabnike in/ali na gospodarsko?*

Z uporabo storitve Direct4.me so na boljšem vse vključene stranke. Spletne trgovine lahko svojim kupcem ponudijo enostavno prejemanje in vračila kupljenih izdelkov. Logistična podjetja lahko dostavijo pakete kadarkoli in si na ta način optimizirajo urnike dostav pošiljk. Naslovniki pa lahko pakete vedno prevzamejo na izbranem mestu, ne glede na to, ali so v času dostave doma, ali ne. Ker dostavljavci odklepajo paketnik s pomočjo NFC ali DOV transakcij, se tudi s tem priučijo novih znanj, ki jih lahko izkoristijo tudi pri drugih produktih ali v zasebnem življenju. Z okolijskega vidika je viden prihranek pri onesnaževanju, saj ni več ponovnih dostav, kar prihrani pri CO2 izpustih. Skratka, pridobimo vsi.

8. Since you have begun implementing new technologies, has there been any change in the structure of your employees? If yes, how?
   Odkar implementirate nove tehnologije, ali se spreminja struktura zaposlenih? Če da, kako?

Da. Kot že rečeno, smo na povsem novo delovno mesto zaposlili strokovnjaka, ki je polno zaposlen za implementacijo sistema za vodenje projektov Jira. Pa tudi programerjev zaposlujemo vedno več, ker je potreba po tovrstnih rešitvah vedno večja. Imamo tudi novo ekipo programerjev mobilnih aplikacij, ki jih pred leti v podjetju Kivi Com nismo imeli.

9. Was there any job task shift at your company?
   Ali je v preteklih nekaj letih prišlo do kakšne prekvalifikacije na delovnem mestu?

En delavec, ki je bil sicer že prej zaposlen v IT oddelku, se je postopoma z internim izobraževanjem vedno bolj preusmeril v programiranje in zdaj aktivno dela kot programer spletnih aplikacij.

10. How does this affect existing employees?
    Kako to vpliva na obstoječe zaposlene?

Ob potrebi novega kadra najprej preverimo znotraj podjetja, če bi bilo morda bolj smiselno, da nekoga, ki je že utečen v procese podjetja, primerno izobrazimo, da z novo pridobljenim znanjem zadostuje novim potrebam.

11. What about the newly recruited employees? Do their competences and skills adequately fit your requirements?
    Kaj pa novi zaposleni? Kako se kompetence in znanja kandidatov skladajo z vašimi potrebami?

Redno sodelujemo s fakulteto za računalništvo in informatiko v Mariboru tako s predstavitvami, kot tudi dejanskimi projekti, na katere se lahko študentje prijavijo. Na ta način študente tekom projekta dodobra spoznamo, in jih, če so se izkazali kot zanimivi, tudi zaposlimo. S tem tudi sami pripomoremo k temu, da zaposlujemo posameznike, ki našim potrebam najbolj ustrezajo.

11.1. What is your experience like, are they mostly adequately prepared or not?
Kakšne so izkušnje, so večinoma primerno pripravljeni ali ne?

Hmm. Čisto odvisno od generacije do generacije. Letos smo prav na ta način zaposlili študentko, ki je v okviru študijskega projekta pomagala na našem projektu. Za enkrat smo precej zadovoljni. Imamo pa večje probleme najti primerne kadre za administracijske pozicije in vodje projektov.

11.2. Why is that?
Zakaj je temu tako?

Ker je narava dela takšna, da je smiselno, če znajo tudi vodje projektov osnovno znanje računalništva, predvsem kar se tiče vnašanja vsebin na spletne strani, podporo strankam in podobno. S tem ne pade vedno vse na programerje. Je pa žal posameznikov, ki združujejo znanje iz obeh področij manj, kot bi si želeli.

12. How do you bridge the gap between candidates' skills and your needs? How do employees adapt to changes in the company?
Kako rešujete vrzel med znanji kandidatov in obstoječih zaposlenih in vaših potreb? Kako se zaposleni prilagajajo na spremembe v podjetju?

Obstoječe zaposlene vse pogosteje pošiljamo na delavnice in izobraževanja v zvezi z informacijskimi tehnologijami. Tu je govora predvsem o posameznikih, ki so dnevno povezani s tehnološkimi rešitvami, a po izobrazbi niso razvojniki. Prav tako občasno na izobraževanja vključujemo tudi programerje, saj je koristno, da posodobijo svoje znanje. Na ta način ostajamo relevantni tudi na področju tehnologije.

Kar se tiče novih zaposlenih pa jih kot rečeno pogosto kot študente vključujemo v delovni proces že v okviru šolanja in jih s tem pripravimo na dejansko delo, ki se vsekakor do neke mere razlikuje od tega, kar so se izučili na fakulteti. Novo zaposleni posamezniki tudi v okviru podjetja dobijo neuradnega mentorja, ki skrbi za njihov razvoj predvsem v prvih mesecih zaposlenosti.

13. What kind of effect did you notice the fourth industrial revolution has on the labour market?
Kako vidite vpliv četrte industrijske revolucije na trg dela?

Do neke mere kot pričakovano. Vedno večja je potreba po naravoslovnih in tehničnih kadrih, predvsem pri novih poklicih kot so AI strokovnjaki, podatkovni znanstveniki in podobno. To pa se ne odraža dovolj hitro na trgu dela. Mislim, da bi morali mlade že prej usmerjati v tovrstne poklice z raznimi delavnicami v okviru osnovnošolskega in srednješolskega izobraževanja in jim predstaviti prednosti teh poklicev, kar vključuje tudi dobre pogoje za zaposlitev.

14. Have you ever encountered a digital security incident at your company? If yes, what happened, what were the consequences?
    Ali ste v podjetju že izkusili incident na področju digitalne. Če da, kaj se je zgodilo, kakšne so bile posledice?

Za enkrat smo imeli na srečo bližnje srečanje z digitalnim vdorom le enkrat. Zakrožil je namreč e-mail, ki je pod pretvezo, da prihaja s strani sodelavke iz finančnega oddelka, pozval k prijavi na spletno stran s svojim uporabniškim računom. V trenutku nepazljivosti je to eden od zaposlenih res storil, ampak nam na srečo niso ničesar ukradli ali izbrisali. Sistemski administrator je odreagiral hitro in ponastavili smo vsa gesla ter avtentikacijo.

15. How do you currently handle digital/cyber security at your company? Does your company have any specific job positions or a department that deals with digital/cyber security? Any rules, regulations, certificates?
    Kako trenutno skrbite za digitalno varnost? Imate posebna pravila ali kakšen certifikat?

Za enkrat še v podjetju nimamo specialistov za digitalno varnost, smo pa s partnerskim podjetjem skupaj v postopku ISO presoje. Kar se tiče pravilnikov v zvezi z digitalno varnostjo, skrbimo za omejen pretok informacij izven podjetja, računalnike imamo opremljene s programsko varnostno opremo. Kar se tiče varnosti našega produkta, imamo strokovnjake za kriptiranje podatkov, s čimer preprečujemo raznovrstne načine prestrezanja digitalnih ključev, s katerimi uporabniki odpirajo svoje pametne predalčnike.

16. How large would you estimate is the impact of digital security on your operations?
    Kakšen vpliv oziroma tveganje predstavlja digitalna varnost za vaše poslovanje?

Digitalna varnost je ključnega pomena predvsem zaradi varnosti naše storitve. Uporabniki nam zaupajo, da so njihovi paketi zaklenjeni v pametne predalčnike, do katerih lahko dostopajo le oni z edinim digitalnim ključem, ki le-te odpira.

16.1. Do you plan on dedicating a larger budget for this purpose in the future?
Nameravate v prihodnosti investirati več denarja za ta namen?

Težko reči. Trenutno smo v fazi masovnega lansiranja projekta, tako da je še vse v zraku. Vsekakor nameravamo narediti vse, da bo zagotovljena ustrezna varnost sistema.

17. You said you have experiences with recruiting university graduates? What are they like? How do they compare with candidates without a formal degree?
    Pravite, da imate izkušnje z zaposlovanjem diplomantov univerzitetnih programov? Kakšne so izkušnje? Kako se primerjajo s kandidati brez formalne visokošolske izobrazbe?

Da, veliko, predvsem programerjev. Na splošno bi rekel, da se obnesejo dobro, saj jih dosti pride k nam že v okviru projektnega dela v povezavi s fakulteto in se v tem času priučijo naših metod dela. Tiste, ki se najbolje izkažejo seveda na koncu zaposlimo in ostanejo pri nas še vrsto let.

Zaposlenih brez formalne izobrazbe imamo v IT oddelku manj, tisti, ki pa so, pa se prav tako naučijo našega dela s pomočjo internega mentorstva. Če bi jih moral primerjati, bi morda rekel, da imajo tisti s formalno izobrazbo kvalitetnejšo osnovo, so pa morda tisti, ki so se učili sami, bolj na tekočem s trendi.

18. How would you assess the knowledge relevancy of the new university graduates?
    Kako bi ocenili ažurnost znanja kandidatov diplomantov?

V splošnem smo precej zadovoljni z ažurnostjo znanja. IT svet se premika zelo hitro, a so po naših izkušnjah tudi novopečeni diplomanti pripravljeni raziskati nove programe in sisteme na lastno pest.

19. What share of your employees perform jobs for which they obtained formal training? In which department is the share the greatest and in which is it the smallest?
    Kolikšen delež vaših zaposlenih opravlja delo, za katerega so se izobraževali? Kje je delež teh večji, v katerih enotah je največji in v katerih je najmanjši?

V razvojnem oddelku bolj ali manj vsi. Zgodba je drugačna pri vodstvenih kadrih in vodjih projektov, saj so ti prihajajo iz raznoraznih vetrov – vse od ekonomistov in pravnikov pa do strojnikov in tekstopiscev.

20. Students of which field are the most up to date and ready for your requirements as an employer? Which are the least ready?
    Na katerem strokovnem področju se vam zdijo diplomanti najmanj/najbolj pripravljeni na vaše potrebe kot delodajalec?

Morda so najbolj pripravljeni prav programerji. Ampak kot rečeno, jih vsaj kar se tiče študentov večino v osnovi vzamemo k sebi na prakso že v času študija in se lahko na tak način prilagodijo na naš način dela. Mislim, da noben kader ne izstopa negativno.

21. Which knowledge areas do graduates lack the most?
Katera področja ali znanja najbolj pogrešate?

Verjetno še najbolj pogrešam kvalitetnejšo komunikativnosti pri kadrih v razvojnem oddelku.

22. Did you or your company ever have direct or indirect benefits from state/policy measures? (e.g. tax treatments, co-financing, technical assistance, recruitment, mediation in business, cooperation with educational institutions). How? If not, why not? (no interest from the company side, poor understanding of policy, bureaucratic obstacles...).
Ali ste že imeli neposredne oz. posredne koristi od javnih ukrepov na vašem področju (davčna obravnava, sofinanciranje, tehnična pomoč, iskanje kadrov, facilitiranje poslov, sodelovanje z izobraževalnimi ustanovami)? Kako? Če ne, kje vidite razloge da do tega ni prišlo? (ni interesa s strani podjetja, nerazumevanje politike za potrebe podjetja, birokratske ovire, …)

Ja, večkrat smo se že prijavili in nekajkrat tudi bili deležni sredstev in raznih subvencij s strani EU skladov in podobno. Kar pa se tiče sodelovanja s fakultetami, pa kot sva že govorila. S FERI uspešno sodelujemo že vrsto let, njihove študente vključujemo v lastne projekte ali jim nudimo pomoči in možnosti pisanja diplomske ali magistrske naloge v okviru poslovanja podjetja. Tiste, ki se za res izkažejo na koncu zaposlimo. Obe stranki zelo zadovoljni.

23. Do you have any experience with international markets? Which markets and what is the experience like?
Imate kakšne izkušnje s poslovnim okoljem na drugih trgih? Kateri trgi in kakšna je izkušnja?

Naš projekt trenutno planiramo razširiti na svetovni trg, trenutno pa že vodimo dialoge s potencialnimi investitorji na hrvaškem in luksemburškem tržišču. Prav dosti je v tej fazi težko reči, bi pa izpostavil, da je luksemburška pošta zelo odprta do raznoraznih inovacij, ki bi lahko potencialno izboljšale uporabniško izkušnjo in doprinesle do novih denarnih tokov. Na splošno za enkrat predvsem dobre izkušnje.