UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER THESIS

CHARACTERISTICS OF INDUSTRY 4.0 IN SERBIA AND THE IMPACT OF COVID-19 ON NEW TECHNOLOGY IMPLEMENTATION

Ljubljana, December 2023 NIKOLA JORDOVIĆ

AUTHORSHIP STATEMENT

The undersigned Nikola Jordović, a student at the University of Ljubljana, School of Economics and Business, (hereafter: SEB LU), author of this written final work of studies with the title Characteristics of industry 4.0 in Serbia and the impact of covid-19 on new technology implementation, prepared under supervision of Tjaša Redek, PhD

D E C L A R E

1. this written final work of studies to be based on the results of my own research;

2. the printed form of this written final work of studies to be identical to its electronic form;

3. the text of this written final work of studies to be language-edited and technically in adherence with the SEB LU's Technical Guidelines for Written Works, which means that I cited and / or quoted works and opinions of other authors in this written final work of studies in accordance with the SEB LU's Technical Guidelines for Written Works;

4. to be aware of the fact that plagiarism (in written or graphical form) is a criminal offence and can be prosecuted in accordance with the Criminal Code of the Republic of Slovenia;

5. to be aware of the consequences a proven plagiarism charge based on the this written final work could have for my status at the SEB LU in accordance with the relevant SEB LU Rules;

6. to have obtained all the necessary permits to use the data and works of other authors which are (in written or graphical form) referred to in this written final work of studies and to have clearly marked them;

7. to have acted in accordance with ethical principles during the preparation of this written final work of studies and to have, where necessary, obtained permission of the Ethics Committee;

8. my consent to use the electronic form of this written final work of studies for the detection of content similarity with other written works, using similarity detection software that is connected with the SEB LU Study Information System;

9. to transfer to the University of Ljubljana free of charge, non-exclusively, geographically and time-wise unlimited the right of saving this written final work of studies in the electronic form, the right of its reproduction, as well as the right of making this written final work of studies available to the public on the World Wide Web via the Repository of the University of Ljubljana;

10. my consent to publication of my personal data that are included in this written final work of studies and in this declaration, when this written final work of studies is published.

11. that I have verified the authenticity of the information derived from the records using artificial intelligence tools.

Ljubljana, December 15th, 2023 Author's signature _____

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AI – Artificial Intelligence

AR – Augmented Reality

CEE – Central and Eastern Europe

CEFTA – Central European Free Trade Agreement

CPS – Cyber-Physical Systems

CUM – Cumulative

DESI – Digital Economy and Society Index

DII – Digital Intensity Index

DL – Deep Learning

EU – European Union

EUR – Euro

FDI – Foreign Direct Investment

GDP – Gross Domestic Product

HICP – Harmonised Index of Consumer Prices

ICT – Information and Communication Technologies

IIoT – The Industrial Internet of Things

IoT – The Internet of Things

IR1 – The first industrial revolution

IR2 – The second industrial revolution

IR3 – The third industrial revolution

Industry 4.0 – The Fourth Industrial Revolution

IT – Informational Technologies

KMO – Kaiser-Meyer-Olkin Measure of Sampling Adequacy

ML – Machine Learning

NATO – North Atlantic Treaty Organization

OT – Operational Technologies

RPA – Robotic process automation

SFRY – Socialist Federal Republic of Yugoslavia

STEM – Science, Technology, Engineering, and Mathematics

UN – United Nations

UNSC – United Nations Security Council

USD – United States Dollar

VAR – Variance

VR – Virtual Reality

WB – Western Balkans

Y-O-Y – Year over Year

1 INTRODUCTION

In the exploration of the Fourth Industrial Revolution, commonly referred to as Industry 4.0, a shift is observed in how businesses operate in the digital age. This transformation introduces advanced technologies, presenting benefits such as heightened productivity, process transparency, innovative business models, improved product quality, and enhanced workplace conditions. The integration of products and machines in this revolution optimizes operations, reduces costs, and saves resources. Real-time insights gained through smart monitoring enable businesses to adapt to dynamic market changes.

However, the impact of Industry 4.0 on companies is uncertain due to challenges like information technology security, data protection, organizing work, skill gaps, training employees, and the need for standardized practices in the digital economy.

This study aims to explore the Industry 4.0, discovering its potential and understanding how it affects businesses. An overview of the key technologies involved, such as the Internet of Things (IoT), Artificial Intelligence (AI), and Machine Learning (ML), will be provided, along with explanations of how these technologies can be leveraged. Furthermore, I will dive into this complex topic, considering both the opportunities for efficiency and innovation and the challenges related to security and skills.

In the pages ahead, I will, also, explain what Industry 4.0 means, its different aspects, and how companies can use it to grow while addressing its risks. The changes brought by Industry 4.0 go beyond just using new technology, they transform how companies operate, how workplaces function, and how business models are designed. A strategic and comprehensive approach is essential for businesses to succeed in this new era.

The goal of the study is to provide practical insights and actionable recommendations that companies, regardless of their size or expertise, can embrace. The motivation behind this exploration is to understand the primary drivers that encourage companies to invest in advanced technologies, the attitudes and perceptions of managers towards the implementation of Industry 4.0 technologies, and to identify the characteristics of new technology implementation at an organizational level and the motives of managers.

In conclusion, by doing this, I hope not only to expand the current knowledge base surrounding Industry 4.0 but also to provide valuable insights and recommendations for businesses.

2 THE FOURTH INDUSTRIAL REVOLUTION

In the first section of the thesis, the discussion will begin with the definition of Industry 4.0 with a brief overview of the first three industrial revolutions. The focus of the first part will be on Industry 4.0 technologies with a special interest in smart factories and the manufacturing sector. The first industrial revolution (IR1), or the age of mechanical production, took place during the late 18th and 19th centuries. It started in Great Britain, the world`s greatest economy and colonial power at the time, fuelled by the game-changing use of steam power. Although the British strongly prohibited transferring their technology and skilled workers to other nations, by the 19th century IR1 spread to the rest of the world, mainly to other Western European countries and the United States. IR1 is considered one of the most distinguished turning points in human history as it created a new era (Khan, 2008).

The second industrial revolution (IR2), or the age of science and mass production, is usually dated between 1870 and 1914. IR2 is also considered an American Industrial Revolution because it began in the USA. Later it spread throughout many other parts of the world mainly to Western European countries. Great inventions and rapid advances happened during the IR2. Electricity, internal combustion engine, the chemical industries, petroleum, and other chemicals helped for easier mass-production of consumer goods including weapons. It became far easier to get around on trains, automobiles, and bicycles. At the same time, ideas and news spread via newspapers, the radio, and the telegraph. Life got a whole lot faster (Mohajan, 2020).

The third industrial revolution (IR3), or digital revolution, began in the 1950s and is characterized by the spread of automation and digitization through the use of electronics and computers, the invention of the Internet, and the discovery of nuclear energy. This era witnessed the rise of electronics like never before, from computers to new technologies that enable the automation of industrial processes. Advancements in telecommunications led the way for widespread globalization, which in turn enabled industries to offshore production to low-cost economies and radicalize business models worldwide (Gregory, 2019).

2.1 Introduction to the Fourth Industrial Revolution

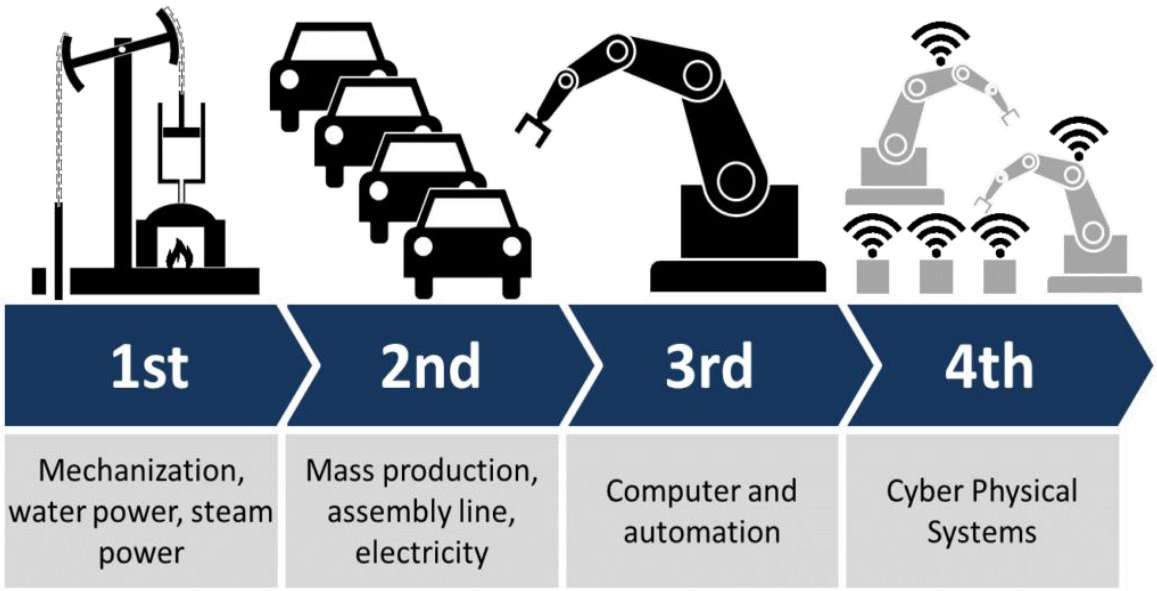
The phrase Fourth Industrial Revolution was first introduced by Schwab (2016) and was one of the main topics that year at the World Economic Forum Annual Meeting. The expression builds on a project originated in 2011 by the German government “The new High-Tech Strategy Innovations for Germany”, which promotes Industry 4.0 and the computerization of manufacturing. The German Federal Government presented Industry 4.0 as a new, emerging structure in which manufacturing and logistics systems in the form of Cyber-Physical Systems (CPS) intensively use the globally available information and

communications network for an extensively automated exchange of information and in which production and business processes are matched (Schroeder, 2016).

The same thing was pointed out by Schwab (2016), who, also characterized industry 4.0 as a fusion of technologies that are blurring the lines between the physical, digital, and biological spheres.

The fourth industrial revolution heralds an era of immense potential for innovation and growth. Illustrated in Figure 1, the convergence of cyber-physical systems marks the union of the physical and the digital realms, giving birth to the concept of a digital enterprise. This digital enterprise is not only interconnected but also possesses the capability for comprehensive, data-informed decision-making. Within this digital ecosystem, data collected from physical systems drive intelligent actions in the tangible world. Industry 4.0 paves the way for responding more swiftly to customer needs compared to current practices. It enhances the flexibility, speed, productivity, and quality of the production process. Moreover, it serves as the bedrock for the adoption of new business models, production processes, and various innovations. This transformation is poised to facilitate a new level of mass customization, as an increasing number of industrial producers invest in Industry 4.0 technologies to refine and tailor their offerings (Deloitte Touche Tohmatsu, 2019).

Figure 1: Different stages of industrial production



Source: Deloitte Touche Tohmatsu (2019).

2.2 Technologies Related to Industry 4.0

In the realm of Industry 4.0, a transformative wave of technological innovation is reshaping the landscape of manufacturing and industrial processes. At the core of this paradigm shift is a set of technologies that are driving unprecedented automation, connectivity, and

intelligence. These technologies have the capability to connect, communicate, and analyse data autonomously. Industry 4.0 facilitates the seamless collection and analysis of data from various machines, resulting in faster, more flexible, and efficient processes, ultimately leading to the production of high-quality goods at reduced costs. This technological shift is not only enhancing manufacturing productivity but also reshaping economic dynamics, spurring industrial growth, and reshaping the workforce landscape, thereby influencing the competitiveness of companies and regions (Wang et al., 2022).

Big data analytics involves collecting, storing, processing, and analysing vast amounts of data from multiple sources like sensors, production lines, and supply chains. This technology uncovers patterns and trends in real-time or historical data, enabling data-driven decisions. For example, predictive maintenance uses big data analytics to anticipate equipment failures, reducing downtime and costs. In the context of Industry 4.0, comprehensive data collection and evaluation from various sources, including production equipment, systems, and customer management, is supporting real-time decision-making, optimizing production quality, saving energy, and improving equipment service (Wang et al., 2022)

The cloud provides on-demand access to a network of remote servers for data storage, management, and processing. Manufacturers leverage cloud solutions to store and manage their ever-growing datasets, making them accessible from anywhere with an internet connection. This facilitates collaborative work, scalability, and the deployment of advanced analytics tools and machine learning algorithms for data analysis (Nair et al., 2021)

Artificial Intelligence (AI) is a branch of computer science that aims to create systems or machines capable of performing tasks that typically require human intelligence. These tasks include problem-solving, understanding natural language, recognizing patterns, and making decisions based on data. AI encompasses a wide range of techniques, including Machine Learning and Deep Learning, to enable machines to mimic human-like intelligence (Woschank et al., 2020).

Machine Learning (ML) is a subset of AI that focuses on developing algorithms and statistical models that enable computers to learn from and make predictions or decisions based on data. ML algorithms can improve their performance over time as they are exposed to more data, making them valuable for tasks such as pattern recognition, classification, regression, and recommendation systems (Woschank et al., 2020).

Deep Learning (DL) is a subfield of ML that employs neural networks with multiple layers (deep neural networks) to process and extract features from large and complex datasets. DL is particularly suited for tasks like image and speech recognition, natural language processing, and autonomous decision-making. Its depth and capacity to model sophisticated patterns contribute to its effectiveness in various Industry 4.0 applications (Woschank et al., 2020).

Horizontal and vertical system integration involves connecting various processes and components within a manufacturing operation. Vertical integration extends this connectivity vertically through all levels of an organization, from the shop floor to top management. These integrations enable real-time data sharing and transparency, improving coordination, efficiency, and decision-making (Zheng et al., 2021).

Robotics is pivotal in automating manufacturing processes. Advanced robots are designed to work alongside humans (collaborative robots or cobots) and perform tasks with precision, speed, and adaptability. They handle repetitive and labour-intensive jobs, boosting productivity and product consistency (Nair et al., 2021)

Augmented Reality (AR) and Virtual Reality (VR). AR enriches the real world by overlaying digital data onto physical environments, enhancing tasks like maintenance and training in manufacturing. VR immerses users in entirely digital environments, proving invaluable for training, design, and prototyping. Together, AR and VR empower Industry 4.0 by improving decision-making, reducing training periods, fostering collaboration, and providing immersive experiences that enhance manufacturing and industrial processes (Javaid et al., 2020).

Additive manufacturing (3D printing). 3D printing builds objects layer by layer from digital designs. This technology offers greater design flexibility, shorter prototyping times, and reduced material waste compared to traditional manufacturing methods. It is widely used in producing complex components and prototypes (Zheng et al., 2021).

Digital Twin is a virtual replica of a physical system or product. Manufacturers create digital twins to simulate and analyze real-world operations. By monitoring the digital twin's behaviour, they can gain insights into performance, identify potential issues, and test modifications before implementing them in the physical world. This technology is valuable for predictive maintenance and optimization (Javaid et al., 2020).

The Internet of Things (IoT) involves connecting physical devices, sensors, and machines to the Internet. In manufacturing, IoT enables the collection of real-time data on equipment performance, product quality, and logistics. This data is used for monitoring, predictive maintenance, and process optimization. IoT enhances visibility, efficiency, and responsiveness across the supply chain (Nair et al., 2021).

It is worth nothing that Industry 4.0 is a dynamic and ever-evolving field, characterized by continuous technological advancements and innovations. As such, the foundational technologies discussed here represent the current state of the industry. However, it's essential to remain vigilant, as new technologies and ground-breaking innovations may emerge, potentially reshaping the landscape of Industry 4.0 in the future (Deloitte Touche Tohmatsu, 2019).

2.2.1 Smart factories in Industry 4.0

Smart factories are at the forefront of Industry 4.0 and represent a major evolution in the way manufacturing is performed. They utilize advanced technologies to create a highly automated and digitized environment for production. The result is a factory that is capable of self-awareness, self-prediction, self-comparison, self-reconfiguration, and self-maintenance, providing significant benefits to both the manufacturer and the consumer (Arden et al., 2021).

By integrating information and communication technology, smart factories can monitor, control, and optimize all aspects of the production process in real-time. This level of automation and digitization increases efficiency and reduces downtime, leading to higher productivity and improved quality. In addition, smart factories can quickly respond to changes in demand, allowing manufacturers to bring new products to market faster and with greater flexibility (Deloitte Touche Tohmatsu, 2019).

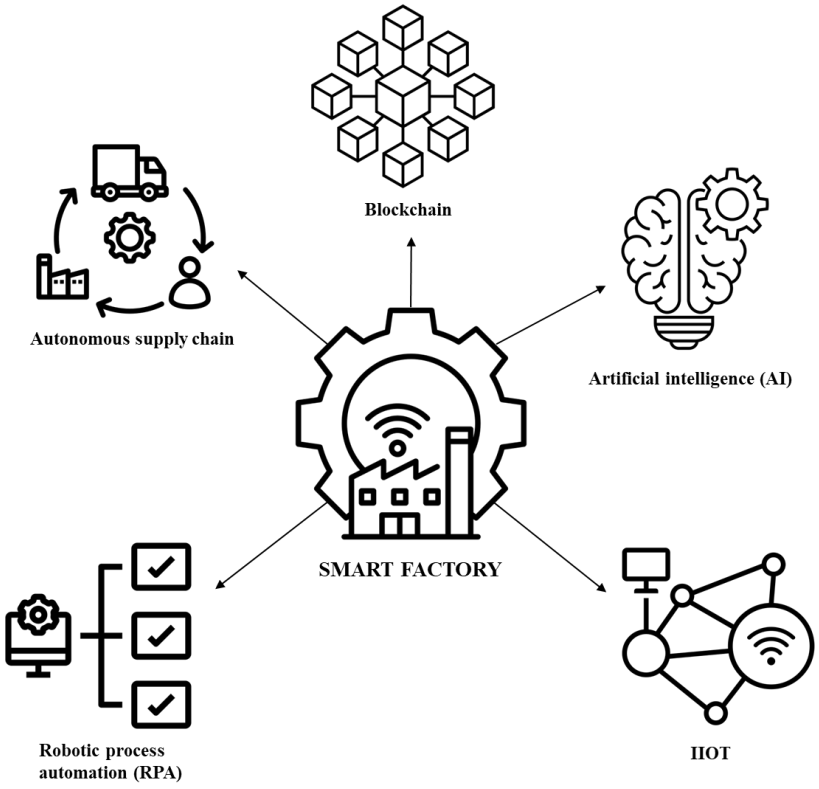
The use of self-monitoring machines and systems in smart factories enables the prediction of potential problems and the implementation of preventative measures before they occur. This results in a reduction in maintenance costs and a lower risk of production disruptions. Overall, smart factories bring a new level of efficiency, accuracy, and cost-effectiveness to the manufacturing process, providing a competitive advantage to companies that adopt this technology (Deloitte Touche Tohmatsu, 2019).

The true power of the smart factory lies in its ability to evolve and grow along with the changing needs of the organization whether they be shifting customer demand, expansion into new markets, development of new products or services, more predictive and responsive approaches to operations and maintenance, incorporation of new processes or technologies, or near-real-time changes to production. Because of more powerful computing and analytical capabilities along with broader ecosystems of smart, connected assets, smart factories can enable organizations to adapt to changes in ways that would have been difficult, if not impossible, to do so before. Manufacturers can implement the smart factory in many ways both inside and outside the four walls of the factory and reconfigure it to adjust as existing priorities change or new ones emerge. The specific impacts of the smart factory on manufacturing processes will likely be different for each organization (Arden et al., 2021).

2.2.2 Technologies enabling smart factory implementation

Bellow we will delve into the various technologies that are driving the implementation of smart factories in Industry 4.0. The use of these technologies is key to realizing the full potential of smart factories and by their implementation we are enabling the transformation of traditional factories into smart ones.

Figure 2: Technologies enabling smart factory implementation



Source: Own work based on Deloitte Touche Tohmatsu (2019); Sulavik & Waller (2020); Javaid et al. (2020); Nair et al. (2021); Wang et al. (2022)

2.2.2.1 Blockchain

The new generation of intelligent Industry 4.0 relies on automation and hyper-connectivity. Thus, hyper-connectivity represents one of the main weaknesses of Industry 4.0. Blockchain embodies this innovation and represents a potential antidote to the cybersecurity risk of Industry 4.0.

In a blockchain, once data is recorded in a block, it becomes extremely challenging to change it. Each block contains specific data, the block's unique hash (like a fingerprint for the block), and the hash of the previous block. The exact nature of the data within a block depends on the type of blockchain. When a block is created, its hash is computed. This hash acts as a unique identifier, much like a fingerprint, and it represents the entire block and its contents. Any modification to the data inside the block would result in a change in its hash. Essentially, hashes are invaluable for detecting any unauthorized alterations to blocks. If a block's fingerprint changes, it signifies that it is no longer the same block. The third crucial component within each block is the hash of the previous block. This interconnected structure forms a chain of blocks. The remarkable aspect is that if you attempt to alter a single block,

it renders all the subsequent blocks invalid. This robust security mechanism is one of the key features that make a blockchain exceptionally secure (Catts, 2019).

Blockchain has the potential to disrupt many industrial sectors and to change the way business is done. When blockchain word is mentioned the first thing that comes to mind is bitcoins, payments, and transactions. But when talking to the industry leaders, one can realize there are so many problems in the industry that can be solved by leveraging blockchain kind of technology. When talking about the manufacturing sector there are two specific uses of blockchain technology: distribution chain risk management (smart contracts that are ideal for managing the risk of the distribution chain) and industrial security IOT (the blockchain provides a way to register and verify each device in a highly connected IIOT equipment network) (Wang et al., 2022).

Because smart contracts are stored inside a blockchain everything is completely distributed, with this technique no one is in control of the money. Because smart contracts are stored on a blockchain they inherit some interesting properties. They are immutable, and they are distributed. Being immutable means that once a smart contract is created it can never be changed. That means that no one can go behind back and tamper with the code of the contract. Being distributed means that the output of the contract is validated by everyone on the network. So, a single person cannot force the contract to release the funds because other people on the network will spot this attempt and mark it as invalid. Tampering with smart contracts becomes almost impossible (Khan et al., 2021).

Industrial security IOT - Traceability is another big issue for both suppliers and users. Supply disruptions caused a ton of loss for manufacturers because the parts didn`t arrive on time or they did not have the right instructions with them sometimes again in sensitive industries, like aerospace, they didn't come with the right certification and why does that happen, because, through the chain of suppliers, someone somewhere missed published the right certificate along with the goods. The availability of the parts in the value chain sometimes is not known in real time because the systems are not connected. In a blockchain scenario, this entire chain of players exists on a single network, they can publish their stock positions they can publish where the stock is and they are also able to publish the right technical documentation and certificates along with it as well as quality tests of the products (Khan et al., 2021)

2.2.2.2 Artificial intelligence (AI)

Table 1 outlines key improvements in industrial processes through the integration of AI. These enhancements encompass predictive maintenance for reducing downtime, AI-driven quality control to refine product quality and minimize waste, supply chain optimization through AI data analysis, predictive analytics for informed decision-making, human-robot collaboration facilitated by AI, process automation to streamline tasks, and real-time decision support. This comprehensive utilization of AI technologies signifies a

transformative impact across diverse industrial domains, optimizing production processes, fostering efficiency, adaptability, and improving overall performance (Deloitte Touche Tohmatsu, 2019).

Table 1: How AI can help transforming traditional factories into smart factories

IMPROVEMENT	SHORT DESCRIPTION
Predictive Maintenance	Using AI to predict maintenance needs to reduce downtime and improve efficiency
Quality Control	AI monitoring of production processes to improve product quality and reduce waste
Supply Chain Optimization	AI analysis of supply chain data to optimize production and improve delivery times
Predictive Analytics	AI-based analysis of data to make predictions about demand, production, and resource utilization
Human-Robot Collaboration	AI enables safe and efficient collaboration between humans and robots
Process Automation	AI automating routine tasks to free up human resources
Decision Support	AI provides real-time decision support to improve decision-making and performance

Source: Deloitte Touche Tohmatsu (2019).

Furthermore, AI technology facilitates the development of new models, means, and forms in the domain of intelligent manufacturing. New models: Internet-based, service-oriented, collaborative, customizable, flexible, and socialized intelligent manufacturing system that is used to facilitate production and provide services to users. New means: human-machine integrated smart manufacturing systems featuring digitalisation, virtualization, service, collaboration, customization, flexibility, and intelligence. New form: intelligent manufacturing ecology with the characteristics of ubiquitous interconnection, data-drivenness, cross-border integration, autonomous intelligence, and mass innovation. The deep integration of the application of these models, means, and forms will ultimately form an ecosystem of intelligent manufacturing (Woschank et al., 2020).

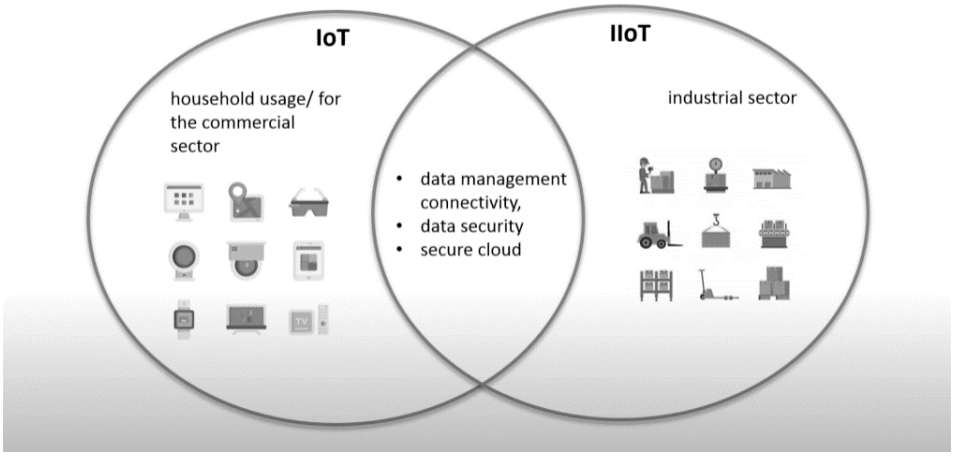
2.2.2.3 Industrial Internet of Things

The Internet of Things (IoT) is most known for consumer usage and is usually depicted as the disruptive technology for solving most of the present-day societal issues such as smart cities, intelligent transportation, pollution monitoring, and connected healthcare, to name a few. As a subset of IoT, Industrial IoT (IIoT) covers the domains of machine-to-machine

(M2M) and industrial communication technologies with automation applications (Deloitte Touche Tohmatsu, 2019).

As shown in Figure 3 the main difference between IIoT and IoT is their general usage. IIoT paves the way for a better understanding of the manufacturing process, thereby enabling efficient and sustainable production and connecting all the industrial assets, including machines and control systems, with the information systems and the business processes. Both IoT and IIoT are communication-based ecosystems that use intelligent and connected devices, thus IIoT uses more sensitive and precise sensors including more location-aware technologies with sophisticated advanced controls in analytics (Deloitte Touche Tohmatsu, 2019).

Figure 3: Internet of Things (IoT) & Industrial Internet of Things (IIoT)



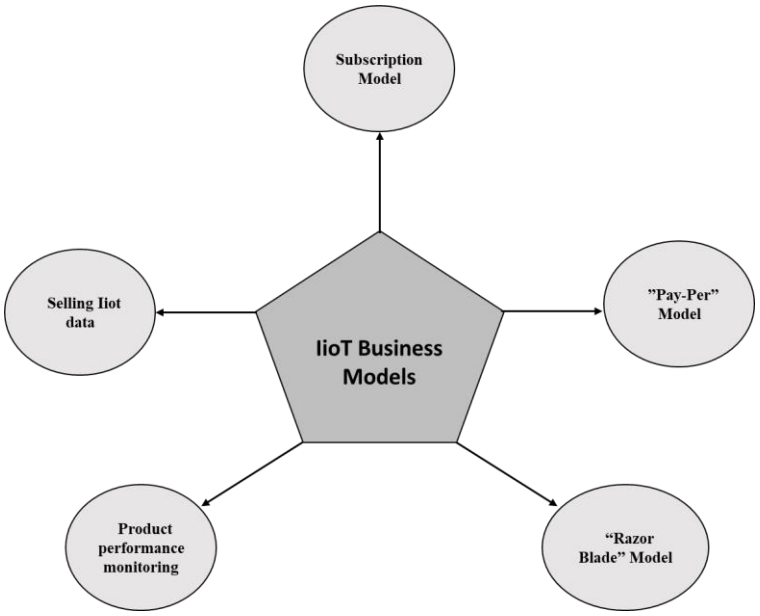
Source: Deloitte Touche Tohmatsu (2019).

Major differences between IoT and IIoT also include the scale of operation and volume of data gathered. IoT generates medium to high volumes of data while IIoT generates massive amounts of data (ex. a single turbine compressor blade can generate more than 500 gigabytes of data per day). IIoT includes big data, cloud computing and machine learning as necessary computing requirements. IoT consumer-level devices have a low risk of impact when failure happens, they may be important for convenience, but breakdowns do not immediately create emergencies. Since IIoT connects critical machines and sensors in high-stake industries, for example, such as aerospace, defence, healthcare, or energy these are the systems in which failure often results in life-threatening or other emergencies (Nair et al., 2021).

If used properly IIoT has the potential to be an integrator of all business touches: from sales, distribution to operations, inventory management, supply networks, to customer service. New business models expand from traditional ones, they offer IIoT-generated data and services, insights and solutions that derive from that data. With such a business models companies aim to attract new customers (as well as new relationships with existing customers) and new shareholders. Business models may be best tested on a small scale to

demonstrate success on several levels, including customer buy-in, ROI, gaining a competitive advantage in a company's traditional market, or possibly capturing market share in an entirely different market or industry (Nair et al., 2021).

Figure 4: Industrial Internet of Things business models



Source: Own work based on Sisinni et al. (2018); Elizalde (2018); Insights Team (2018); Viorel (2019).

Subscription Model, since IoT products can be connected all the time with their customers, manufacturers can leverage that connectivity to develop a recurring-revenue business model. This business model empowers manufacturers to actively participate in a relationship with their customers, unlike the traditional manufacturers who rarely interact with their customers once the sale of the product is completed (Elizalde, 2018).

Peloton, a high-end indoor bicycle manufacturer uses a subscription model as additional income to their revenues. Besides selling a base product for roughly $2,000, the bicycle is equipped with a Wi-Fi-enabled, 22-inch touchscreen tablet. Peloton also streams live and on-demand classes, which at-home users can connect to via Peloton's servers. The content comes with an annual subscription of $400+. They also added a freemium model to their product introducing different apps on their tablet device. With more than 150,000 bikes sold, that adds up to yearly subscription revenue of more than $70 million (Insights Team, 2018).

"Pay-Per" Model, IoT-enabled products provide various "pay-per" offerings, including pay-per-hour of output, pay-per-alert, pay-per-insight, pay-per-warning, and pay-per-solution. This is a very innovative model where the goal is not to make money on the device itself. Instead, manufacturers are using data produced by the IoT device and by tracking usage they are charging a fee. By monitoring sensors embedded in the products themselves manufacturer also collects data for constant analysis of the product's performance and condition in real-time (Sisinni et al., 2018).

The best-known example of the ”Pay-Per” model is used by British company Rolls-Royce. They use the “power by the hour” business model, where throughout the “Total Care program” they rent jet engines instead of selling them. Rolls-Royce retains ownership and charges customers on a fixed dollar-per-flying-hour basis. Rolls-Royce constantly collects large amounts of data on an engine’s performance, and based on that company actively manages the engine through its life cycle to achieve maximum flying availability. The program also saves on fuel costs and reduces environmental impact since the collected data, and the associated analytics, keep engines running at peak efficiency (Insights Team, 2018).

In the “Razor Blade” Model, most equipment providers do not make a lot of profit when selling their machines. They make their money by supporting ongoing operations. First, parts break and must be regularly replaced. Second, hardware must be maintained and serviced. Finally, consumables like blades, fluids, fuels, adhesives, inks, and other materials are used up and re-ordered. In this model, a manufacturer might sell the IoT product at cost or even at a loss since the goal is to get the product in the customer’s hands, so they can start selling their other products (Viorel, 2019).

In the product performance monitoring business model, customers would get access to data that is collected from a sensor connected to an IoT device. They can periodically check-up in real-time a product performance and efficiency as well as get notifications for predictive maintenance. Companies can charge a separate premium for apps or web-based tools, cybersecurity, data storage, and software updates, or charge an upfront premium for the IoT-enabled product at the point of sale (Viorel, 2019).

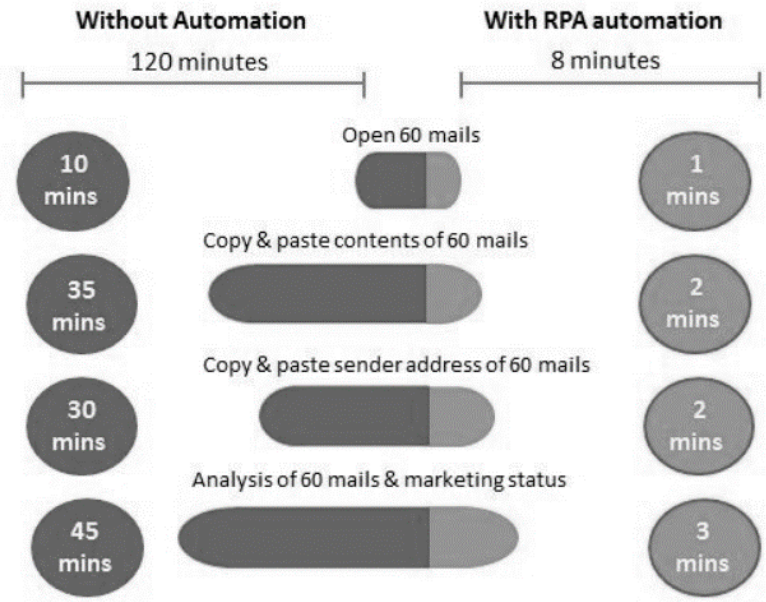
Selling IioT data is another business model, the best examples of this business model are Facebook and Instagram. They collect a huge amount of data from their users and sell it to third-party companies (usually advertisers) that use the data to promote their products and services (Elizalde, 2018).

2.2.2.4 Robotic process automation (RPA)

Robotic process automation (RPA) is a process of automating tasks or processes with the help of robots or software, to reduce human intervention. These bots (i.e., autonomous programs that can interact with systems or users) can either just follow the rules defined by the user or can use the machine learning capabilities to suggest a user with recommendations and generate meaningful results. RPA can be used to automate an enormous number of tasks in the field such as human resources, financial service, healthcare, supply chain management, customer service, accounting etc. Each industry can use RPA in its own way to reduce the manual workforce and work with better efficiency. RPA is applied in the industry using a great number of tools, these are software applications that can configure tests and automate them (Javaid et al., 2020).

As showed in Figure 5, a basic task, such as opening emails, copying content, and sending it to different addresses, requires only eight minutes when automated RPA. In contrast, the same task takes a significant amount of time, 120 minutes,when performed without automation. This highlights the substantial time efficiency gained through RPA in streamlining routine tasks.

Figure 5: Simple task performed without automation and with RPA automation



Source: Javaid et al. (2020).

RPA offers numerous advantages, including increased accuracy, as RPA software is generally less prone to errors and operates with high precision and uniformity. It ensures consistency by performing repetitive tasks in the same manner, even through countless repetitions. Additionally, RPA serves as a cost-reducing technology by minimizing manual workforce requirements, leading to reduced task-related expenses. The technology also contributes to a high productivity rate, significantly decreasing the time required to execute tasks compared to manual approaches. Another benefit is the minimal coding requirement for RPA software, making it accessible without extensive programming knowledge. This results in reduced operational risks, as the consistent and error-free output enhances customer satisfaction. In terms of delivery, RPA plays a crucial role in decreasing average delivery time, thereby improving the overall customer experience and ensuring 24/7 business continuity while controlling costs (Javaid et al., 2020).

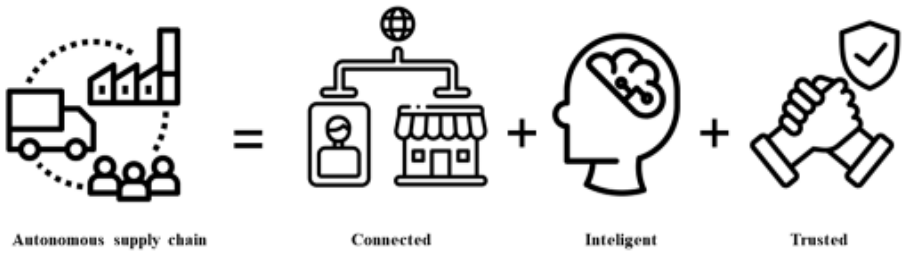
2.2.2.5 Digitization of supply chain (autonomous supply chain)

Using the potential of advanced Industry 4.0 technologies is not just simply shifting or shortening the supply chains but also making them smarter and faster. The data is gathered in near-real-time and smart analysis and algorithms allow for better simulation and

prediction of different supply chain scenarios. With data-based decision-making, supply chains are not just becoming automated but also autonomous, which means they are starting to act with limited human intervention, with the final goal of being self-orchestrated and self-learning (Sulavik & Waller, 2020).

A digital supply chain has the potential to become an integral part of business transformation and a source of real competitive advantage, that is why developing advanced supply chain capabilities makes strong economic sense, helps increase product quality and gives companies the agility needed to respond to disruptions. Some of the biggest advantages of a digital supply chain are strategic, such as improved planning, better quality, and higher levels of customer satisfaction and retention. Other benefits are financial, such as greater profitability and asset utilisation. Yet others are operational, such as accelerated time to market and reduced time to delivery. As highlighted in Figure 6, an autonomous supply chain is characterized by being connected, intelligent, and trusted, underlying the essence of its transformative potential (Geissbauer et al., 2020).

Figure 6: Autonomous supply chain



Source: Geissbauer et al. (2020).

Many Industry 4.0 integrators look at new disruptive technologies individually. The real value to the supply chain comes from combining these technologies. Rather than a linear chain, where data is transferred from one stage to the next, in a digital supply chain data is available continuously throughout the supply chain ecosystem, giving partners near-real-time and simultaneous access to relevant information and enabling optimised and informed decision-making. Companies need to ensure they have an end-to-end digital foundation in place. The digital foundation allows companies to seamlessly exchange electronic business transactions and information through a business ecosystem, with all the trading partners, including suppliers, logistics service providers and customers (Geissbauer et al., 2020).

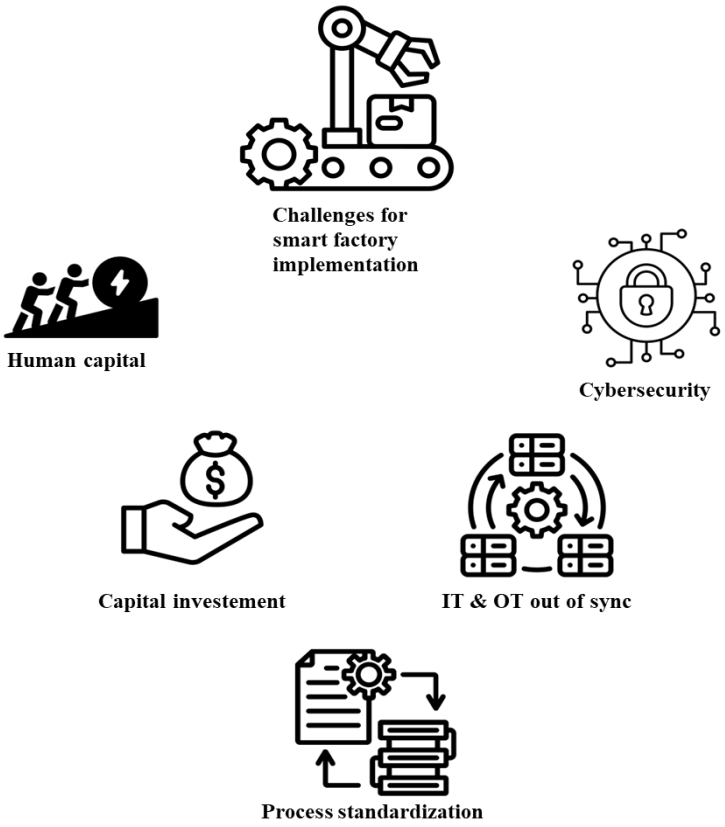
Because products can be traced end-to-end, it makes it possible for companies to meet the increasing demand for greater insight into the environmental and social impact of their products. They can communicate the origin of products to their customers, which in turn will boost confidence in their products. Near-real-time track and trace helps companies manage their supply chains more efficiently and optimise operations. They can manage stock levels

more precisely, as information on the arrival of raw materials or components to production lines, or of finished goods in warehouses, is constantly updated. This makes possible entirely new service offerings and even business models (Sulavik & Waller, 2020).

2.2.3 Challenges in implementing a smart factory in Industry 4.0

Industry 4.0 also brings with it new challenges and risks. Nowhere might this be more apparent than in the manufacturing cybersecurity landscape. The rise of digital technologies and global interconnectivity marks a new level of complexity. According to a Deloitte report by Hajj et al. (2020), the manufacturing sector has been consistently featured among the most frequently targeted sectors for cyber-attacks. Besides cybersecurity, there are rising concerns about legal, financial, privacy, and intellectual property theft, due to a smart manufacturing ecosystem. While the advantages of connectivity include increased levels of productivity, faster identification and remediation of quality defects, and better collaboration across functional areas, they can also multiply the potential vulnerabilities of the smart factory. If these challenges are not appropriately addressed, the true potential of Industry 4.0 may never be achieved.

Figure 7: Key challenges associated with implementing a smart factory in Industry 4.0



Source: Own work based on, Villagrán et al. (2019); Hajj et al.(2020); Mutray (2020); Nair et al. (2021); Storm & Gumbel (2021).

These challenges and risks range from cybersecurity threats to the synchronization of informational technologies (IT) and operational technologies (OT) systems, as well as standardization, capital investment, and human capital issues (Figure 7). The transformation and implementation of new manufacturing processes is a complex endeavour that requires a thorough understanding of the challenges and risks involved.

Cybersecurity and data privacy issues present major challenges and roadblocks for adopters of Industry 4.0 technologies. Implementing a smart factory in Industry 4.0 involves connecting various devices, sensors, and systems to the internet and enabling them to communicate with each other. This connectivity creates a more efficient and flexible production process but also opens new cybersecurity challenges. Smart factories are vulnerable to cyberattacks, which can cause significant damage to the production process, steal intellectual property, or compromise sensitive data (Nair et al., 2021).

The challenge is that the interconnected nature of smart factories means that a single vulnerability in one device or system can potentially compromise the entire network. Additionally, the increased use of cloud computing and third-party services in Industry 4.0 also creates additional cybersecurity risks. Cybercriminals can exploit these vulnerabilities to gain unauthorized access to critical systems, causing production disruptions, financial losses, and reputational damage (Mutray, 2020).

Informational technologies (IT) and operational technologies (OT) are out of sync, and to gain operational efficiency and assure better customer service many companies are looking to unite IT and OT across their operations. Thus, IT and OT are still out of sync, and many manufacturers have difficulties integrating the two of them. In traditional manufacturing, operational technologies allow facilities to operate. Today, these OT systems are being integrated with advanced Industry 4.0 technologies such as sensors and aggregation platforms. The scope of individuals with access to these interconnected OT systems has expanded significantly, encompassing not just shop floor workers but also vendors, suppliers, and business users, often dispersed across various factories and geographic locations. The incorporation of advanced technologies into OT networks requires the establishment of robust cybersecurity standards. With new technologies continuously being introduced to factories through smart factory applications, IT and OT leaders must remain vigilant against emerging threats (Hajj et al., 2020).

Standardization of processes within and among organizations in the new business environment is the key factor for the interconnected world. Technology standards will connect enterprises horizontally and vertically to promote integration among enterprises. There is a rising need to adapt existing standards or create new ones for Industry 4.0. Enterprises continuously improve their technology capabilities and quickly convert them into patents. In this way, they can set up technology barriers and make competition rules to gain the initiative in competition. Industry 4.0 recognizes that self-managing production processes require open software and communications standards that allow sensors,

controllers, people, machines, equipment, logistics systems, and products to communicate and cooperate directly. Future automation systems must adopt open-source multivendor interoperability software applications and communication standards like those that exist for computers, the internet, and cell phones. For the globally operating enterprises, the definition of technical requirements in globally standardized systems is of particular importance. The aim is to gradually anchor all the essential specifications for uniform technical function and applicability in international standards (Villagrán et al., 2019).

The implementation of Industry 4.0 requires a capital investment. The costs can vary significantly, ranging from the relatively inexpensive integration of IoT sensors on existing machinery to substantial investments in large machinery equipped with comprehensive Industry 4.0 solutions. The price tag associated with establishing a smart factory can span from several million to hundreds of millions of dollars. While the capital investment for more extensive projects may pose challenges to the balance sheet in the short term, it is crucial to recognize the potential long-term benefits. Despite initial financial impacts, these investments are poised to yield a multiplying effect over time (Nair et al., 2021).

According to Nair et al., (2021) listed are some of the main costs associated with smart factory implementation:

- Technology procurement and implementation costs, including hardware and software components such as sensors, robots, and AI systems.
- Upgrading or retrofitting existing equipment and infrastructure to accommodate new technology.
- Training and retraining of employees to use new technology and processes.
- Integration and testing of new systems and processes to ensure seamless operation.
- Data management and analysis systems to support decision-making (Nair et al., 2021).

In the face of significant changes in work dynamics, the workforce, and workplace structures, organizations must embrace a reinvention process where human capital transformation plays a crucial role. To navigate this transformation effectively, leaders should re-envision their workforce strategies. This involves rethinking how work is structured and exploring the advantages of these changes. Fostering workforce development is crucial, promoting continuous learning seamlessly integrated into employees' lives, ultimately creating a more adaptable and resilient workforce. The workforce experience should evolve continually, focusing on ensuring that individuals feel supported, interconnected, and deeply engaged in shaping the organization's future. Moreover, the workplace itself should be designed to enhance productivity and collaboration, delivering added value to the organization and, by extension, to the broader environment (Storm & Gumbel, 2021).

3 THE DEVELOPMENT OF SERBIAN ECONOMY AND ITS TECHNOLOGICAL PROGRESS

A turbulent period in the 1990s, the end of Yugoslavia, wars in Bosnia and Croatia, UN sanctions, hyperinflation, and NATO bombing, severely damaged the Serbian economy and particularly its industry. Although, some experts, pointing to various reasons, claim that Serbia is three to five technological generations behind (roughly between 25 to 30 years) advanced countries the industrial growth from the last couple of years with the support of foreign investments, tells us that industrial production could go back to levels of the pre-war period (Andrejić, 2019),

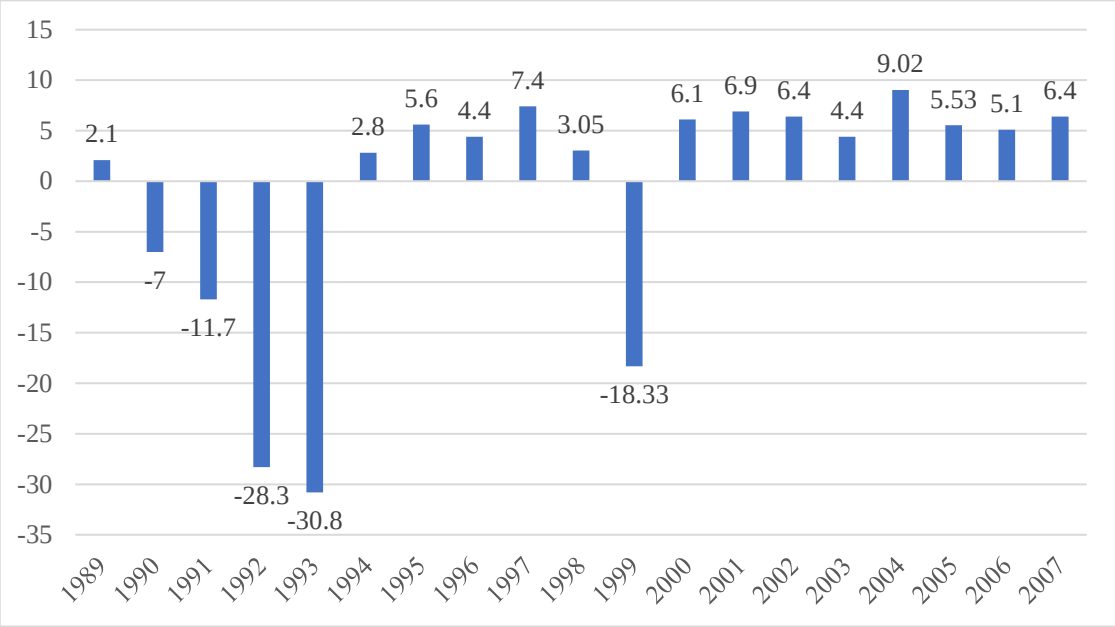
3.1 Economic Development in Serbia

3.1.1 General economic overview

The beginning of the last decade of the 20th century led to a real collapse of the Serbian economy. It started with the disintegration of the common state (SFRY). The single market has disappeared and economic ties between business partners have been severed. Due to the civil war in Bosnia and Herzegovina (BiH), the United Nations Security Council (UNSC), by Resolution 757, imposed sanctions on the Federal Republic of Yugoslavia (FRY), on May 30, 1992. During the four years of these sanctions, they primarily affected ordinary citizens and had great economic consequences.

As shown in Figure 8, there was a big drop in GDP, already in 1990 compared to 1989, the GDP decreased by seven per cent; the drop continued by 11.7 per cent in 1991; in 1992 the year of the introduction of sanctions, the economy fell by an additional 28.3 per cent compared to the previous year; and during the year of hyperinflation in 1993, it additionally collapsed by another 30.8 per cent. After the introduction of sanctions, the FRY will have hyperinflation of incredible proportions. In the period from 1992 to 1994, hyperinflation was recorded, which ranks third in world economic history both in terms of duration of 22 months (March 1992 - January 1994) and in terms of the maximum monthly level of 314 million per cent. A slight recovery of the economy began in 1994, it accelerated until 1997 when Serbian Telecom was sold, and growth peaked at 7.4 per cent. At the end of 1998, the country's economy was just over half of 1989 levels. However, a new bombing happened in 1999, this time by NATO. The economy shrank by another 18 per cent, and Serbia entered 2000 with an economy of 41.7 per cent from the level of 1989. Also, the total industrial production was 44.1 per cent lower in 2000 compared to 1989 (Nikolić, 2017).

Figure 8: Real GDP growth rate (1989-2007) in Serbia



Source: Nikolić (2017).

The start of the 21st century brought big political and economic reforms for Serbia. On 5th October 2000, after 55 years socialistic regime fell from its place of power. This was the official start of a transition period for the Serbian economy, which however did not go as fast and successful as in some countries of the former Eastern block. The deep roots of the Serbian economic collapse go back to the socialist regime because many things were built outside and independent of the real requirements of the market. This means that a good number of those organizations that emerged at that time were not sustainable and could not fit into an open market economy. In addition to the already mentioned sanctions in the 1990s, where Serbia was cut off from all major foreign trading partners, in the period 1989-2000, total investments fell sharply and averaged only 12.5 per cent of GDP. This level is far below the level required to preserve the real value of capital, whereas levels of investment of around 18 per cent are enough to just cover depreciation costs. Observed by activities, low investments, especially hard hit the industry, an activity in whose capital equipment has a high share, and where technological progress during the 1990s was strong around the world (Zdravković, 2020).

Furthermore, there were a huge number of workers who were formally employed but completely unproductive. For productivity to remain at least at the same level as in 1989, the number of employees needed to follow the decline in GDP during the 1990s, meaning that Serbia had to reduce the number of employees by the same percentage as a decline in GDP, which is over 50 per cent. As a result of the gap between GDP and employment, productivity fell by as much as 50 per cent between 1989 and 2000. This means that with the 1989 level of productivity GDP in 2000 could have been made with around 1.3 million employees, while actual employment was 2.25 million. The economic value of capital

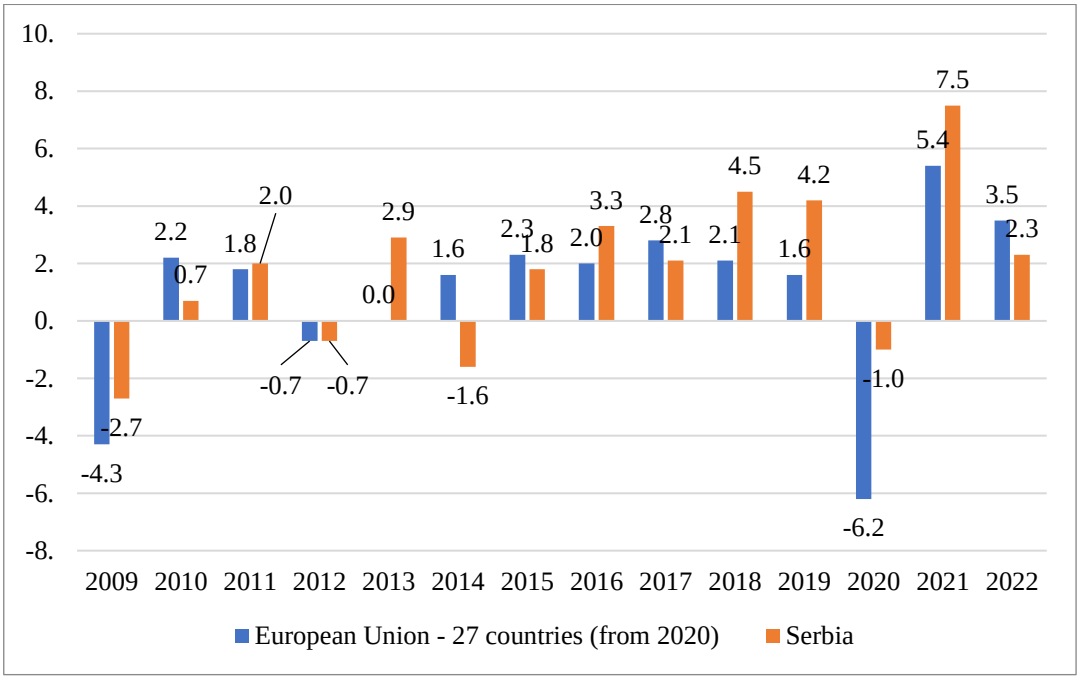
continued to decline in the period 2001-2003 but at a much slower pace. The total decrease in the value of capital in the period 2001-2004 was about 4 per cent, or about 1 per cent per year, which is significantly less than the depreciation rate of 4.5 per cent per year during the 1990s. The reduction and then the end of the decline in the value of capital is the result of an increase in the investment rate, which was in the period 2001-2004, 17 per cent on average, with the investment rate growing from year to year so that in 2004 it reached a level of 21 per cent. It is estimated that in the period 2004-2008. year, the total capital in the Serbian economy increased by about 15 per cent. This was reflected by year-to-year growth in GDP with an average of 6.2 per cent for the period 2000-2008 with a peak in 2004 where the real GDP growth rate was 9.02 per cent. This phase, which lasted eight years, is the only period of significant economic growth for Serbia during the last two and a half decades, during which GDP cumulatively increased by 58 per cent. However, this growth was predominantly driven by FDI, which was significantly lower in the years following the world economic crisis (Arsić, 2016).

Being one of 90 countries that went into economic recession in 2009 because of the 2008 global financial crisis, Serbia recorded a decline in the real GDP growth rate that year of -2.7 per cent. Cumulative GDP growth in Serbia in the period after the economic crisis, 2009-2020, was about 10 per cent, while other countries in the region in the same period had cumulative growth of about 20 per cent. The main reason is that Serbia has chosen the wrong path to recover from the crisis. Until 2015, the Serbian government tried to encourage greater economic activity by increasing consumption, which was not right because the products of the Serbian economy were not at a sufficient level of development compared to foreign products. This path was wrong because in that period the Serbian economy was the only one in Europe to go into recession three times - 2009, 2012 and 2014 (although the last time was mostly due to natural disasters). Only since 2015, has the economy entered a phase of a positive trend, primarily due to the introduction of certain economic measures, investments in infrastructure and capital investments that attract a large number of FDI (Eurostat, 2023).

As shown in Figure 9 in 2016, Serbia's GDP growth reached 3.3 per cent and the country achieved a fiscal balance, recording a budget surplus for the first time since the global economic crisis. There was also a decline in public debt relative to the percentage of GDP growth and a rise in government revenues. This trend lasted until 2019. In addition to the already mentioned domestic measures of fiscal consolidation, the biggest contribution to this progress was the positive trend of the EU`s economy in that period, which spilled over to Serbia and the region. In 2020 the real GDP growth rate was expected to grow, following the trends of 2018 and 2019, however, due to the global crisis caused by COVID-19 Serbian economy went into recession and a decrease of one per cent was recorded (Eurostat, 2023). The adopted economic policy measures (5.8 billion euros, about 12.5 per cent of GDP in 2020 and the additional package of about 2 billion euros in 2021) managed to limit the effect of the crisis and minimize the economic downturn. The stimulus that has been put forward by the Serbian government during the COVID-19 crisis is the largest one in the Western

Balkans. In 2021 Serbian economy recovered, resulting in a 7.5 per cent increase in real GDP growth having a prediction of sustainable increase of about four per cent in the medium term. However, this medium-term outlook is crucially dependent on international developments, the pace of structural reforms, and political developments. 2022 was one more very turbulent year which resulted in significantly lower real GDP growth than projected of just 2.3 per cent (National Bank of Serbia, 2023).

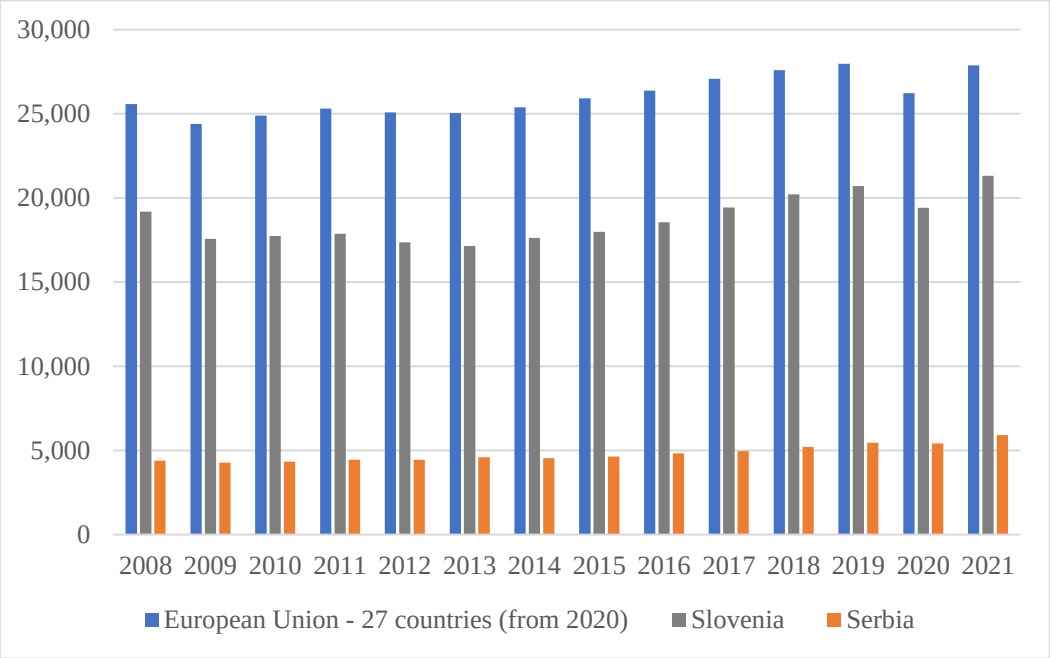
Figure 9: Real GDP growth rate, Y-O-Y change in per cent, 2009-2022



Source: Eurostat (2023).

Figure 10 shows real GDP per capita which in Serbia reached EUR 5.910 in 2021, compared to the EU27 average of EUR 27.880 and Slovenia`s EUR 21.310. The total GDP of Serbia at market prices in 2021 was EUR 46.467 million compared to Slovenia`s EUR 46.297 million, whereas Slovenia has four times less population than Serbia. When it comes to purchasing power parity for actual individual consumption, an indicator that helps in the determination of living standards, the last known data show that in 2021 in Slovenia the index was 88 while in Serbia only 62.6 with EU-27 being the index of 100. Although the standard of living of the Serbian population remains significantly below the EU-27 average the authorities have the support of the European Union and international financial institutions to modernise infrastructure and support investment in the business community. According to Eurostat data, the percentage of people living at risk of poverty or social exclusion had a downward trend from 2013 (which is the first known data for Serbia) to 2021, going from 42 per cent to 24.9 per cent, respectively. Just for comparison that percentage for EU-27 in 2021 was 21.7 per cent (Eurostat, 2023).

Figure 10: Real GDP per capita, in EUR, 2008-2021



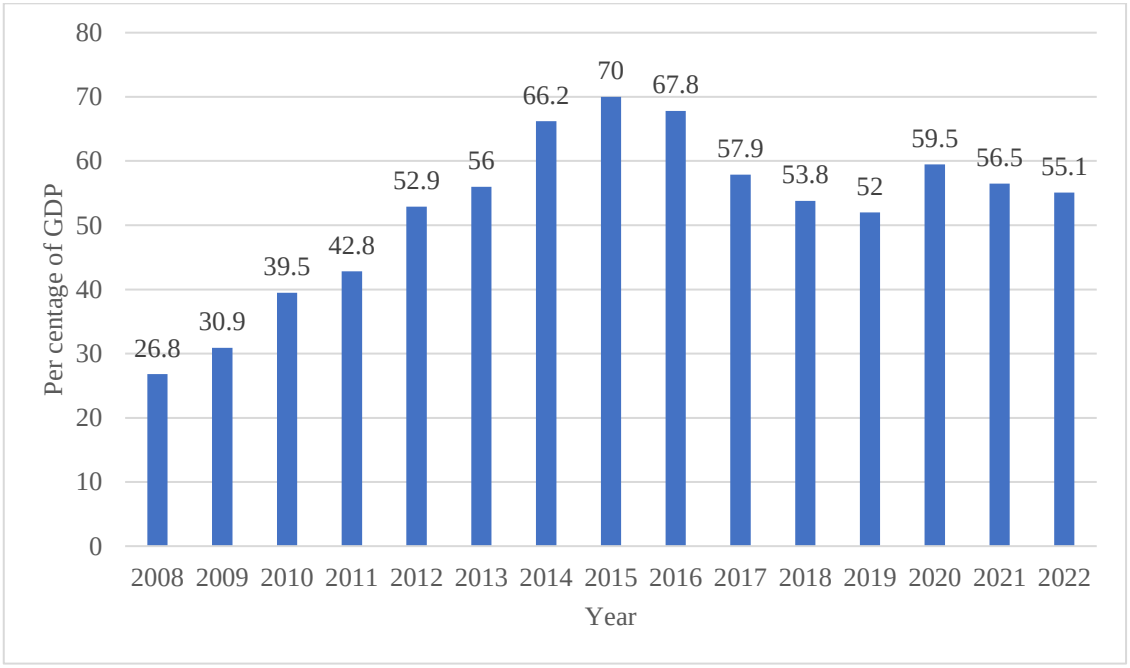
Source: Eurostat (2023).

The Serbian economy suffered a severe downturn in the aftermath of the 2008 global financial crisis. Sources of financing dried up, leading to a significant drop in investment. Consumption also declined drastically, exposing the flaws of the pre-crisis growth model that had led to unsustainable debt levels. Political will for change weakened and even allowed some important policy reversals. Severe weather conditions, both floods and droughts, hit Serbia hard as well in 2014 and 2015. As shown in Figure 11 these events affected an increase in Serbia`s public debt from 26.8 per cent of GDP in 2008 to 70 per cent in 2015 (National Bank of Serbia, 2023).

2015 was a turning point when Serbian leaders found the will to implement a four-year fiscal stabilization program. Reforms included a reduction in public sector spending: wage and pension cuts, a hiring freeze, and reduced spending on subsidies and guarantees to SOEs. In addition, reforms to make the labour market more flexible and to improve business regulations were also implemented. High deficits of over 6 per cent of GDP were turned into a surplus as of 2017 and public debt declined from its peak of 70 per cent in 2015 to 52 per cent in 2019 (National Bank of Serbia, 2023).

In 2020 public debt rose to 59.5 per cent of GDP, this trend is due to the public support the government has put in place to cope with the negative economic effects of the pandemic. The programme funded the purchase of equipment, boosting entrepreneurship through development projects, it also provided other types of support for start-ups and young and female entrepreneurs. This support in turn helped in a decrease of public debt to a level of 56.5 per cent in 2021 with a further decline to 55.1 per cent in 2022 (National Bank of Serbia, 2023).

Figure 11: Public debt in Serbia as a percentage of GDP, 2008-2022



Source: National Bank of Serbia (2023).

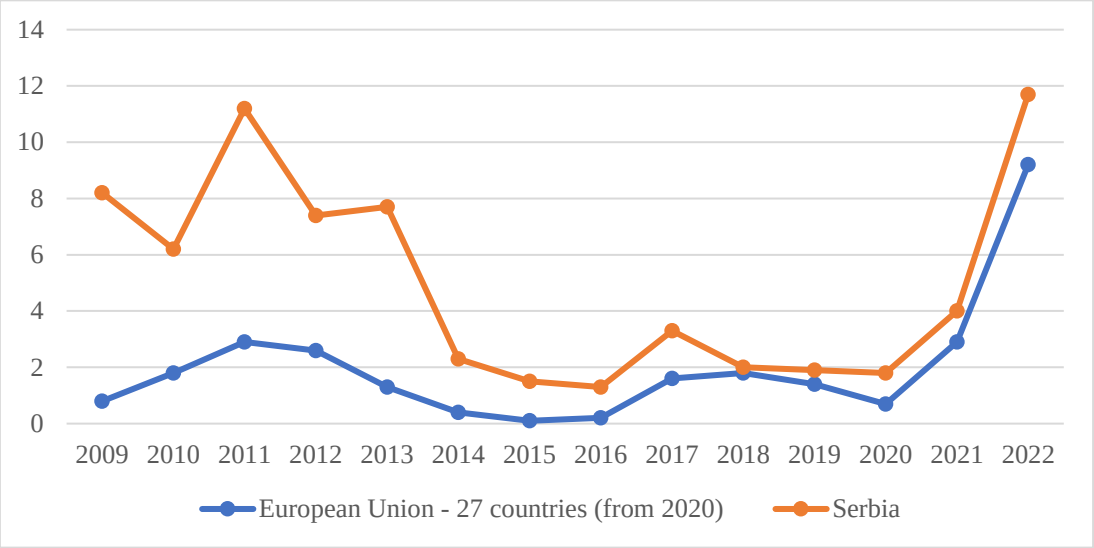
After the 2008 World Economic Crisis inflation in Serbia was very unstable, hitting 11.2 per cent in 2011, Figure 12. However, in the next seven years, inflation was tightly under control, hovering around two per cent on average which is pretty much like the EU27 average. During 2020, and the beginning of the COVID-19 global pandemic inflation remained low and stable and averaged 1.8 per cent at the end of 2020 (Eurostat, 2023).

Even though NBS expected a small increase in inflation in 2021 projecting it to rise to just 2.4 per cent, it has reached the level of four per cent followed by a substantial increase in 2022 of 11.7 per cent hitting a multi-decade maximum in Serbia as well as in many other countries in the world (National Bank of Serbia, 2023).

A bundle of effects have contributed to inflation skyrocketing after the COVID-19 emerged. Increased prices of energy resources (electricity, petroleum products, natural gas, etc.), price increase of industrial raw materials together with the tight situation on the labour market, China's zero COVID-19 policies which contributed to supply-chain disruption, special military operation in Ukraine and uncontrolled printing of money. All these things are still affecting the growth of base inflation in many countries.

However, it is estimated that recovery will follow, which will be reflected by the acceleration of economic growth in China, the gradual balancing of the energy market in Europe, the reduction of global uncertainty, the strengthening of external demand and the further resolution of stagnation in global supply chains (National Bank of Serbia, 2023).

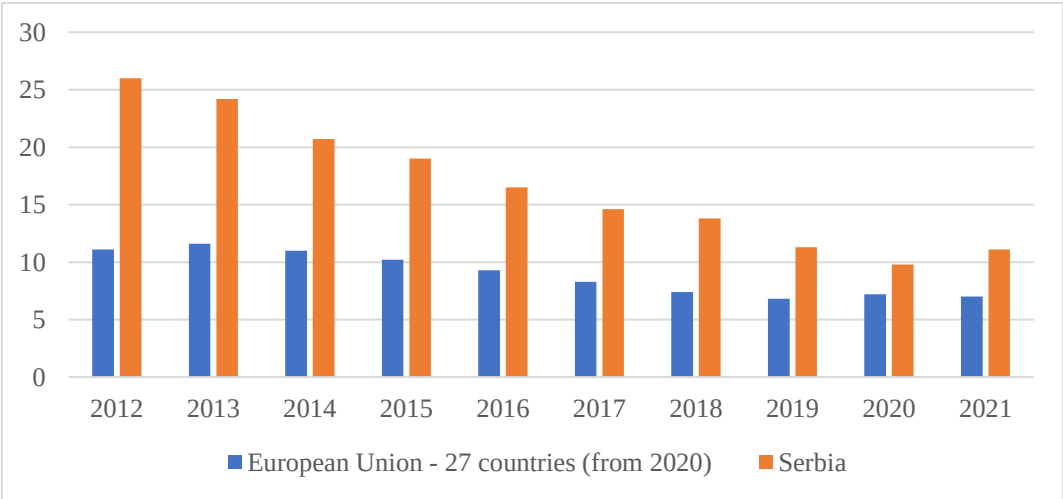
Figure 12: HICP- inflation rate, Y-O-Y change in per cent, 2009-2022



Source: Eurostat (2023).

Serbia's unemployment rate remains significantly higher than the European average. As shown in Figure 13, the unemployment rate in Serbia reached an all-time high of 26 per cent in 2012 after the global economic crisis, and a record low of 9.8 per cent in 2020. The average rate of unemployment for the period from 2012 to 2021 was 16.7 per cent. During the COVID-19 pandemic the largest part of the government's stimulus package (7.4 per cent of GDP) went to businesses and a major reduction in employment was avoided. In 2021 unemployment rate was 11.1 per cent (Eurostat, 2023). However, the unemployment trend is declining, though, it is important to highlight the large immigration of young Serbian citizens mostly to Western European countries (500,000 people immigrated from Serbia for the period 2008-2019) as well as the negative natural increase (during 2020, the number of deaths in Serbia was 53,261 higher than the number of births) (Vasiljević, 2021).

Figure 13: Unemployment as a percentage of the active population, 2008-2021



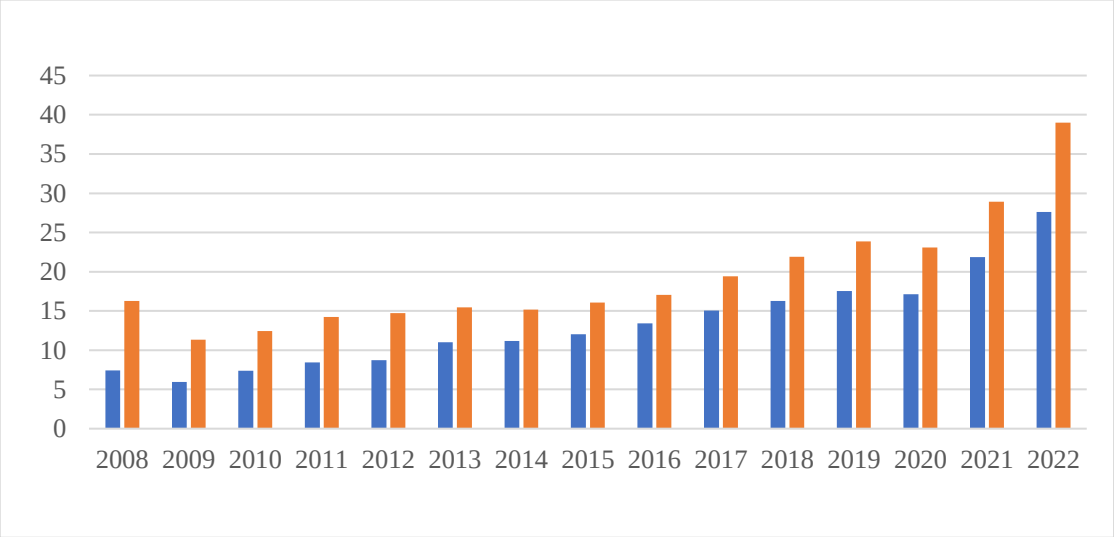
Source: Eurostat (2023).

3.1.2 International trade

The global economy is becoming increasingly interconnected, and international trade is an integral part of this interconnectedness. For a country like Serbia, which has a relatively small domestic market, exports and imports are crucial for its economic growth and development. In recent years, the Serbian economy has become more integrated into the global economy.

As shown in Figure 14, the total foreign trade in 2021 was EUR 50.8 billion and it increased by 26.3 per cent compared to 2020. In 2022 it increased even more recording EUR 66.6 billion with y-o-y growth of 31.2 per cent. Total exports in 2022 were EUR 27.6 billion which is an increase of 26.3 per cent compared to the same period the previous year. Total imports in 2022 were EUR 39 billion which is an increase of 34.8 per cent. The export/import balance is EUR -11.4 billion which represents a 61 per cent increase to 2021 when the balance was EUR -7.1 billion (Statistical Office of the Republic of Serbia, 2023).

Figure 14: Exports and Imports in Serbia, billion EUR, 2008-2022



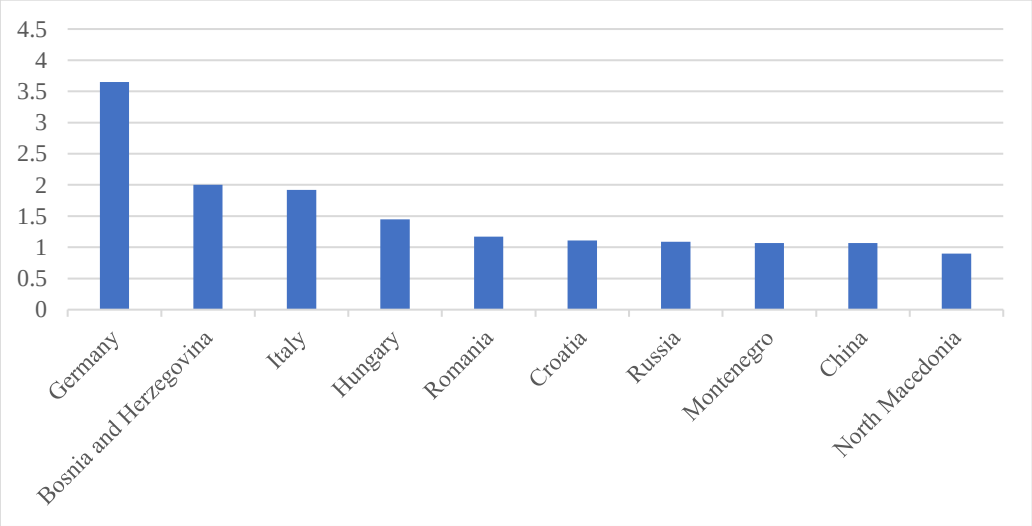
Source: Statistical Office of the Republic of Serbia (2023).

Serbia's exports rely mostly on the EU`s and Balkan`s region demand. The EU countries were the largest trading partners of Serbia. Serbia also has the CEFTA agreement enabling exports of all products originating from Serbia without customs and other fees to the neighbouring countries: Albania, Bosnia and Herzegovina, North Macedonia, Moldova and Montenegro. CEFTA countries are the second largest trading partners of Serbia. In total Serbia exports 88 per cent of its goods to Europe, followed by just 8.6 per cent to Asia and only 2.5 per cent to the Americas.

Figure 15 shows, that by countries, the largest share of exports in 2022 was to Germany EUR 3.65 billion (14 per cent of total exports) followed by Bosnia and Herzegovina EUR 2 billion (7.5 per cent) and Italy EUR 1.92 billion (7.2 per cent). The other countries on the top ten

export partners for 2022 include Hungary, Romania, Croatia, Russia, Montenegro, China, and North Macedonia (Trading Economics, 2023).

Figure 15: Serbia's top ten export partners 2022, billion USD



Source: Trading Economics (2023).

As shown in Table 2 the largest share in exports in 2022 was noted for the following NACE Rev. 2 divisions: manufacture of electrical equipment, EUR 247 million (share of 11.1 per cent); manufacture of food products, EUR 233 million (share of 10.5 per cent); manufacture of motor vehicles and trailers, EUR 185 million (share of 8.3 per cent); manufacture of machinery and equipment n.e.c, EUR 160 million (share of 7.2 per cent); and manufacture of rubber and plastic products, EUR 153 million (share of 6.9 per cent) (Statistical Office of the Republic of Serbia, 2023).

Table 2: Largest exports share by category (NACE) in percent and million EUR, 2022

Exports By Category	Percent	Million USD
Manufacture of electrical equipment	11.1	247
Manufacture of food products	10,5	233
Manufacture of motor vehicles and trailers	8,3	185
Manufacture of machinery and equipment	7,2	160
Manufacture of rubber and plastic products	6,9	153

Source: Statistical Office of the Republic of Serbia (2023).

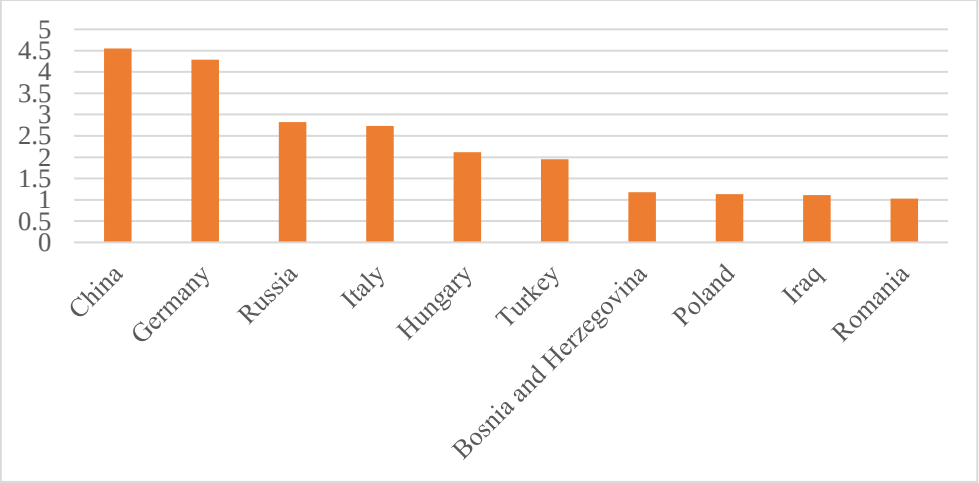
Serbia should expand its exports, where a key potential source for growth lies outside its borders. Serbia introduced only 47 new export goods between 2008 and 2017, and the complexity of its exports did not increase. During the same time, 201 new export products emerged in Croatia and 312 in Lithuania. A very small number of products created in Serbia during this time embed a high level of skills and technology content in their production. At the same time, the complexity of the overall basket of products that Serbia exports have been falling, in favour of raw materials and lower value-added products, like insulated wire, steel,

copper, maize, wheat, tobacco, apples and frozen raspberries. Low complexity and sophistication of exports, and slow improvements in this area, reduce Serbia's ability to compete internationally and signal limited prospects for future increases in exports (Kovačević, 2021).

Half of the Serbian exports originate from foreign-owned firms, which source little domestically. Gains in manufacturing exports have been driven by a few large foreign exporters. Higher exporter concentrations in vehicles, electronic equipment, as well as rubber, plastics and fabricated metals are behind this trend. The "FCA Srbija" (FIAT) plant, a centrepiece of FDI, was not the main catalyser for the development of a thriving auto vehicle parts industry, as it imports most of its parts from abroad. Almost 30 per cent of the increase in exports involves imports of goods for processing in Serbia, with products then being exported back to the country of origin. These create few possibilities for participation in the global value chains for local companies (Kovačević, 2021).

Most of the imports come from EU countries (about 55 per cent), then from the Asian countries (25 per cent) and CEFTA (4.4 per cent). By country, in 2022 as shown in Figure 16, the largest share of imports is from China EUR 4.55 billion (12 per cent of total imports), while Germany lost its place as the biggest import partner and is now in second place with EUR 4.29 billion or 11 per cent of total imports. On the third place is Russia with EUR 2.82 billion (7.5 per cent) who overtook Italy on the fourth place with EUR 2.73 billion (6.7 per cent). The other countries on the top ten import partners for 2022 include Hungary, Turkey, Bosnia and Herzegovina, Poland, Iraq and Romania (Trading Economics, 2023).

Figure 16: Serbia imports partners 2022, billion EUR



Source: Trading Economics (2023).

Table 3 shows the largest share in imports in 2022 for the following NACE Rev. 2 divisions: extraction of crude petroleum and natural gas, EUR 356 million (share of 11 per cent); manufacture of chemicals and chemical products, EUR 288 million (share of 9 per cent); manufacture of machinery and equipment n.e.c, EUR 257 million (share of 8 per cent);

manufacture of basic metals, EUR 196 million (share of 6 per cent), and manufacture of food products, EUR 184 million (share of 5.7 per cent) (Statistical Office of the Republic of Serbia, 2023).

Table 3: Largest exports share by category (NACE) in percent and million EUR, 2022

Imports By Category	Percent	Million EUR
Extraction of crude petroleum and natural gas	11	356
Manufacture of chemicals and chemical products	9	288
Manufacture of machinery and equipment	8	257
Manufacture of basic metals	6	196
Manufacture of food products	5.7	184

Source: Statistical Office of the Republic of Serbia (2023).

3.1.3 Investments

Investments play a crucial role in the development of a country's economy. The money invested in various sectors can lead to job creation, technological advancements, increased production, and higher productivity, which can ultimately lead to the country's economic growth. Moreover, investments can also contribute to the overall social welfare of the population, as they can lead to the development of healthcare, education, and other essential public services.

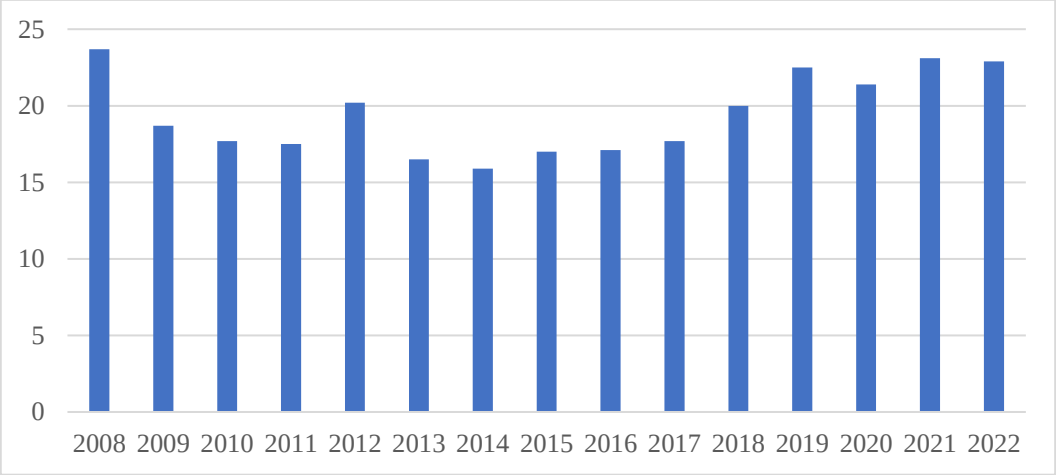
The optimal level of investment in a country's economy depends on several factors, including the country's economic goals, the stage of economic development, and the availability of resources. In general, a country's investment level should be sufficient to finance its economic growth while maintaining financial stability. According to the World Bank, a country's investments should be at least 25 per cent of its gross domestic product (GDP) to sustain economic growth (World Bank, 2023). Data for the countries of Central and Eastern Europe (CEE) show that they had high investment rates of around 25 per cent of GDP during the period of rapid economic growth when they achieved a more noticeable advance towards developed European countries. China, as well as the countries of East Asia, which have achieved great economic growth in the last couple of decades, also had very high investment rates in that period, from 30 to 40 per cent of GDP (Nova ekonomija, 2019).

In contrast, Serbia based its model of economic growth in the previous 20 years mainly on the growth of personal and state consumption, and in certain periods also on the growth of exports, while investments were generally low.

Figure 17 shows share of gross investments in fixed assets in % of GDP. Although in the first phase of the transition, from 2001 to 2008, economic growth was dominantly based on growth in consumption, overall investments in that period still grew, from around 14 per cent of GDP (in 2001) to 23.7 per cent of GDP (in 2008). From 2009 onwards they would

be averaging around 20 per cent of GDP. This is evidently not sufficient enough (Statistical Office of the Republic of Serbia, 2023).

Figure 17: Share of gross investments in fixed assets in % of GDP, 2008-2022



Source: Statistical Office of the Republic of Serbia (2023).

In the long run, the biggest chance that a country has stable and high rates of economic growth is if it can rely on total domestic investment (public and domestic private investment) as well as domestic savings. In the 1990s, the level of total domestic investments fell below ten per cent, which was not enough even to cover depreciation costs. From 2001 to 2008, total domestic investments started to grow slowly, and then there was a global economic crisis that affected the overall decline in investments and thus its stagnation in Serbia. In the period 2015-2022, total domestic investments grew by an average annual rate of about 10 per cent, while their cumulative growth was about 64 per cent (National Bank of Serbia, 2023).

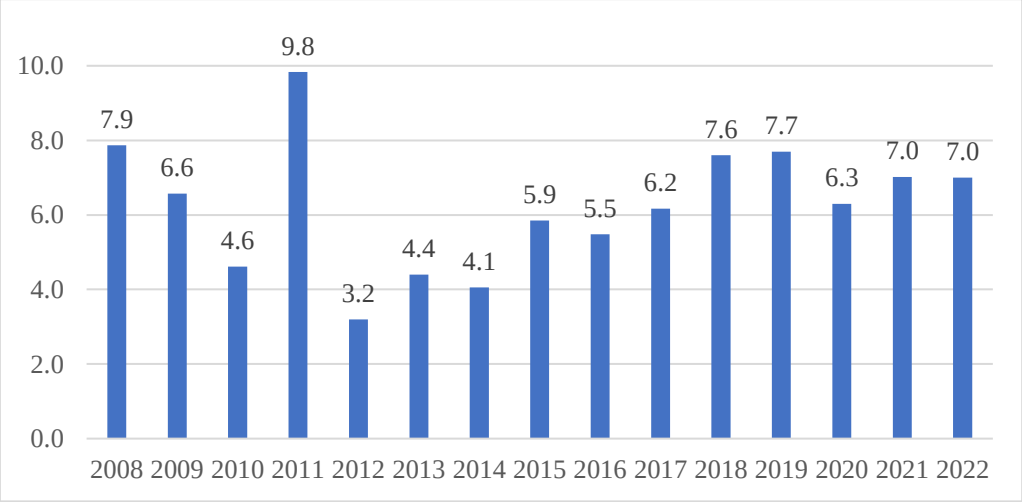
Public investments until 2019 were quite low, in the period from 2001 to 2018 they were less than three per cent of GDP. The situation has been improving since 2019, where in 2019 and 2020 public investments accounted for about five per cent of GDP (which is a good percentage), but they must remain at that level in the long run while improving the efficiency of their implementation (less corruption) (Madžar, 2021).

Domestic private investment has also recorded low growth rates in the last two decades, somewhere around ten per cent of GDP. Several factors affect these results, one of which is low domestic savings from which it can be invested in the economy. In Serbia, the savings rate is below ten per cent of GDP, this rate is insufficient to finance investments to the extent necessary to stimulate dynamic growth. The low savings rate can be justified by the low development of the country where people are unable to save due to low incomes, but this is not a good enough reason because the savings rate in CEE countries, which are comparable economies, is 2.5 times bigger than in Serbia (Nova ekonomija, 2019).

Foreign direct investments (FDI) are a component of a country's total investments, and the dynamics of economic growth in the medium and long term largely depend on them. Macroeconomic and financial stability with structural reforms created a favourable environment for foreign direct investments in Serbia, which are diversified by sectors and countries of origin and contribute to the export potential of the country. FDI have very positive effects, directly in improving the macroeconomic picture of a country, helping in GDP growth rate, positive effects on employment, raising export potential, etc. Indirect effects are in terms of the transfer of new technologies, knowledge, innovation and business culture and they are also very important. However, in the previous two decades, the Serbian model of attracting FDI has been more oriented towards the development of labour-intensive plants, to employ as many workers as possible. There is a very small degree of added value (higher productivity, higher earnings, new technologies, innovations, etc.) that FDI brings to Serbia (Stamenković & Vučković, 2019).

From 2008 to 2022 FDI had an average of 6.2 per cent of GDP which has largely amortized the effect of low public and domestic private investment in the last two decades. Figure 18 shows that in 2011 a record-high foreign direct investment was recorded in terms of the percentage of GDP, 9.8 per cent. However, in the terms of amount of money invested 2022 was a record high with EUR 4.4 billion or seven per cent of total GDP. Among foreign-owned companies that opened in Serbia in 2022, a third are Russian-owned, which is 13 times more than in 2021. Serbia has attracted about 60 per cent of total foreign direct investments in the region of Western Balkans. Manufacturing sectors has the largest inflow of foreign direct investments (metal, car, food, tires) (National Bank of Serbia, 2023).

Figure 18: Foreign direct investments as % of GDP, 2008-2022



Source: UNCTADSTAT (2021).

FDIs are also geographically diversified, with growing participation of countries from the Asia-Pacific region and The Middle East, next to the EU. In 2022 most of the direct foreign investment inflows still originated from Euro Zone countries (45.1 per cent), but with a growing share of Asian countries (16.4 per cent), above all China and UAE, as well as from

European countries outside the EU like Russia, Turkey, and Switzerland (20.8 per cent) (National Bank of Serbia, 2023).

3.2 New Technology Implementation in the Republic of Serbia

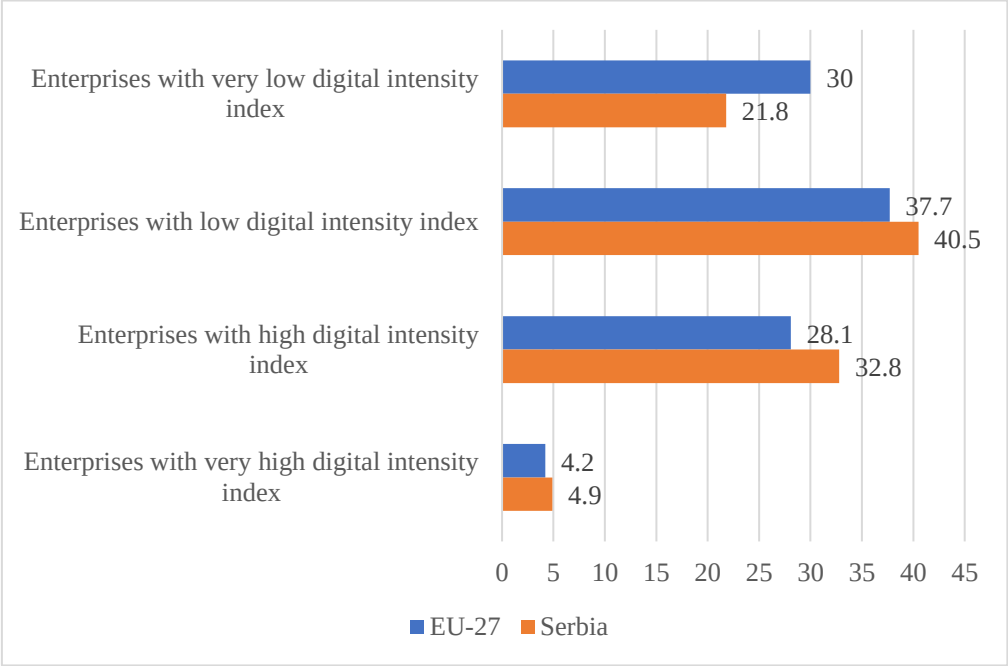
One of the challenges facing the economy in Serbia is certainly digitalisation, which was set as one of the development priorities many years ago. On the other hand, it is at the same time one of the prerequisites in the attempts for Serbia to join the international division of labour under new conditions and to take its place in the world economy where it belongs, according to its capacities and conditions.

On the technological map of Europe, the Republic of Serbia is somewhere in the middle. However, investments in research and development are much lower in Serbia than those in the EU countries and compared to the standard laid down in the Lisbon Convention. The share of the private sector in R&D investments is very low in the Republic of Serbia, and in that respect, Serbia is considerably lagging behind the countries in the region, especially Slovenia (Eurostat, 2023).

The Digital Intensity Index (DII) by Eurostat aims to capture the level of digitalisation in different sectors of the economy. It is based on the proportion of enterprises that use advanced digital technologies, such as cloud computing, social media, and e-commerce, in their business processes. The index is calculated for each economic sector and country, and it can be used to compare the digital performance of different countries.

Like shown in Figure 19, in 2022 in Serbia 32.8 per cent of companies have a high digital intensity index, while 40.5 per cent of them have a low digital intensity index, in both of these categories Serbia is above the EU average. When it comes to companies with a very high digital intensity index, Serbia is almost at par with the EU having 4.9 per cent of companies compared to the EU's 4.2 per cent. What in general puts Serbia above the EU average is being better in the category of companies with very low digital intensity where the EU has 30 per cent while Serbia has just 21.8 per cent (Eurostat,2023).

Figure 19: The digital intensity index of companies in Serbia and to EU27 in per cent, 2022 (10+ employees)



Source: Eurostat (2023).

Table 4 shows the digital intensity by industry in Serbia and EU27 in per cent for 2022 for enterprises with 10 or more employees. The industries presented in the table are Manufacturing, Construction, Retail Trade (except for motor vehicles and motorcycles), Accommodation, and ICT. The table is divided into four categories based on the digital intensity index of the enterprises: very low, low, high, and very high.

In terms of industries with a very low digital intensity index, Serbia exhibits a higher percentage of such enterprises in the Construction, Accommodation, and ICT sectors compared to the EU27. Conversely, the EU27 has a higher proportion of enterprises with very low digital intensity in Manufacturing and Retail Trade.

On the other hand, in terms of industries with a very low digital intensity index, Serbia exhibits a higher percentage of such enterprises in the Construction, Accommodation, and ICT sectors compared to the EU27. Conversely, the EU27 has a higher proportion of enterprises with very low digital intensity in Manufacturing and Retail Trade.

In contrast, enterprises with a high digital intensity index are more prevalent in the Retail Trade and Accommodation industries in Serbia, while the EU27 sees a higher concentration in Manufacturing and ICT sectors. Lastly, for enterprises boasting a very high digital intensity index, Serbia lags behind the EU27 in all industries.

Table 4: The digital intensity by industry in Serbia and EU27 in per cent, 2022 (10+ employees)

Indicator/Industry		Manufacturing	Construction	Retail trade*	Accommodation	ICT
Enterprises with very low digital intensity index	EU27	31,7	43,4	32,5	20	2,2
	Serbia	37	15,4	32,1	6,7	0,2
Enterprises with low digital intensity index	EU27	39,7	42,9	39,2	39	11,8
	Serbia	34,5	63,7	28,6	44,7	3,8
Enterprises with high digital intensity index	EU27	23,7	13,2	23	34,7	72,2
	Serbia	25,5	20,1	35,6	40,1	63,8
Enterprises with very high digital intensity index	EU27	4,9	0,5	5,4	6,3	13,7
	Serbia	3,1	0,8	3,7	8,5	32,2

** except for motor vehicles and motorcycles.*

Source: Eurostat (2023).

While DII measures the digital intensity of specific industries, the Digital Economy and Society Index (DESI) assesses five main dimensions of digital development: connectivity, human capital, use of internet services, integration of digital technology, and digital public services. It provides a comprehensive overview of a country's digital readiness and performance in the digital economy and society. European Commission has been tracking the progress only for Member States, however, Jordanoski & Meyerhoff (2021) analyzed the DESI index for Western Balkan Economies. Serbia is the most prepared economy in WB and was able to provide data for all 37 DESI indicators and thus is marked as highly prepared. In specific areas, Serbia scored relatively high in broadband connectivity, but relatively low in human capital and digital public services. The report highlights the need for improving digital infrastructure, skills, and innovation in the country, however, it's worth noting that the country has made some progress compared to the previous year's report.

4 EMPIRICAL RESEARCH ON THE USE OF INDUSTRY 4.0 IN COMPANIES IN SERBIA

After conducting an extensive literature review and analysing primary data to establish a robust foundation for my empirical research, the choice was made to employ a quantitative approach through the development of a comprehensive questionnaire. In this chapter, I will describe the research objectives and primary research questions. Following this, I will describe the structure and content of the questionnaire.

Subsequently, I will delve into the analysis of the data collected through the survey. This analysis will begin with describing the survey sample, and then proceeding with a detailed examination of the survey questions. Finally, I'll discuss the tests conducted to examine my research hypotheses. This sequential breakdown will facilitate a clear understanding of the research process and the subsequent findings in this chapter.

4.1 Research Objectives

In the empirical analysis, a thorough exploration of Industry 4.0 within Serbian companies was conducted. The research objective aims to provide valuable insights into the characteristics of Industry 4.0, its impact on company development, the motives compelling organisations to invest in these technologies, and the influence of the COVID-19 pandemic on technology implementation.

Industry 4.0 represents a transformative phase for businesses worldwide. As businesses across the world integrate these technologies, they encounter both opportunities and challenges. Serbia, like many other nations, is navigating this dynamic landscape. Because of that, the main goal of the empirical study is to deeply understand the current state of Industry 4.0 technologies in Serbian companies and the challenges and opportunities they face. Research aims to explore its different sides, figure out its features, and understand how these technologies are reshaping and redefining the corporate landscape in Serbia. By doing this, I hope not only to expand the current knowledge base surrounding Industry 4.0 but also to provide valuable insights and recommendations for businesses and policymakers in Serbia.

The research was guided by the following research questions:

- What are the characteristics of Industry 4.0, their impact on firm development and which motives drive firms into Industry 4.0 investment?
- What are the characteristics of the implementation of new technologies at the organisation level and the motives of managers?
- What are the key challenges and barriers firms encounter when implementing Industry 4.0 technologies?
- What are the attitudes and perceptions of managers towards the implementation of Industry 4.0 technologies?
- To what extent have Industry 4.0 technologies influenced the collaboration and partnerships with external stakeholders?
- How did COVID-19 impact investments at large and in particular investments in new technologies and how (in view of managers) will that impact the longer-term development of their companies?

4.2 Questionnaire Structure

Quantitative research forms the core of this study, concentrating on providing a detailed assessment of the state of Industry 4.0 technologies in Serbia, particularly at the company level. Drawing upon insights derived from primary data collected and an extensive analysis of relevant literature, I developed a comprehensive questionnaire that served as a central data collection tool for this research endeavour. The questionnaire, which can be found in Appendix 2, comprises of 19 questions, which were carefully designed to extract insights and data crucial for this study. It incorporates a range of question types, including binary (yes/no), multiple choice, closed-ended, and Likert scale questions, each tailored to capture diverse facets of the research subject. The questionnaire was actively conducted from June 2023 to September 2023.

The questionnaire is organized into eight sections, each focusing on a specific aspect related to Industry 4.0 implementation:

- Advanced technologies: the first part of the questionnaire is dedicated to understanding the advanced technologies currently employed by organizations. Participants are asked to select from a list of technologies, indicating those that are in use within their companies.
- Motives for implementation: this section delves into the alignment of a company's strategy with digitalisation and Industry 4.0. Participants are questioned about the extent to which their corporate strategies encompass these domains. The section also assesses the significance of various factors in implementing Industry 4.0 technologies.
- Influence on decision-making: this segment explores how the adoption of Industry 4.0 technologies has affected decision-making processes and strategic planning within companies. Participants are requested to rate the extent of influence on various key processes.
- Obstacles and challenges: here, participants evaluate the principal obstacles or challenges faced by their companies during the implementation of Industry 4.0 technologies. This section provides valuable insights into the difficulties encountered during the adoption of advanced technologies.
- Management attitudes and most important partners: the management's stance toward Industry 4.0 implementation is examined in this part. Participants are also asked to rate the importance of different collaborators (chamber of commerce, external partners, international organizations etc.) in relation to Industry 4.0 initiatives.
- COVID-19 influence: This part focuses on how the COVID-19 pandemic has impacted the motives for implementing Industry 4.0 technologies within companies. Participants were encouraged to provide specific examples and details regarding this influence.
- Demographics: in the final section, participants provide information about their company, such as its size in terms of employees, annual revenue for the previous fiscal

year, approximate value added per employee, sector, and their role or position within the company. Additionally, the number of years spent with their current employer is asked.

The questions in this questionnaire were constructed based on previous research on Industry 4.0 technologies, notably inspired by the works of Deloitte Touche Tohmatsu (2019), Woschank et al. (2020), Khan et al. (2021), Nair et al. (2021). The questions were adapted from these sources to suit the context of this study.

4.3 Sample Description

The distribution of this survey was executed through a multi-faceted approach. I leveraged LinkedIn as a primary platform for outreach, sharing the survey through posts and various industry-specific groups. Additionally, I employed a more targeted approach, reaching out to executives of Serbian companies directly via private messages and email. To further extend the reach of the survey and ensure a diverse set of responses, I also collaborated with the Serbian Chamber of Commerce, particularly their Industry Sector department.

This comprehensive effort helped in the collection of a substantial sample of n=100 fully completed questionnaires. These responses represent a wide range of perspectives and experiences from professionals across different sectors of the Serbian business landscape. The information obtained from these questionnaires will be instrumental in shedding light on the different aspects of Industry 4.0 in Serbian companies and serve as a foundation for the subsequent analysis and findings of this research.

Understanding the demographics of the questionnaire is crucial as it offers valuable insights into the characteristics of the respondents. This information helps provide a clearer picture of who the survey participants are and allows for a more in-depth analysis of the data. In this section of the survey, encompassing questions 14 through 19, participants were requested to provide specific details about their respective companies. These details included the number of employees, their company's revenue generated in the past fiscal year, the approximate value added per employee, the sector in which their company operates, and their respective roles or positions within the organization.

Table 5 illustrates the distribution of companies based on the number of employees. The majority of surveyed companies, constituting 45 per cent, have over 250 employees, indicating a substantial presence of large organizations. Firms with 10 to 49 employees make up 30 per cent of the sample, while those with 49 to 249 employees and 1 to 9 employees represent 17 per cent and 8 per cent of the sample, respectively. It is worth noting that 70 per cent of respondents who come from large organisations (250+ employees) operate in manufacturing sectors.

Table 5: Number of employees, in % of all respondents

Number of employees	Per cent
1-9	8.0
10-49	30.0
50-249	17.0
250+	45.0

Source: Own work.

Table 6 outlines the distribution of surveyed companies according to their revenue in the last fiscal year. Notably, 36 per cent of the companies reported revenues exceeding 100 million €, signifying a considerable representation of financially robust enterprises. Companies with revenues ranging from 50 million € to 100 million € constitute 23 per cent of the sample, followed by those in the 10 million € to 50 million € range at 18 per cent. Additionally, 15 per cent of companies reported revenues between 1 million € and 10 million €, while 8 per cent reported revenues below 1 million €.

Table 6: Revenue of the company in the last fiscal year, in % of all respondents

	Per cent
Less than million €	8.0
1 million € - 10 million €	15.0
10 million € - 50 million €	18.0
50 million € - 100 million €	23.0
Over 100 million €	36.0

Source: Own work.

Table 7 displays the distribution of survey respondents according to the approximate value added per employee in their companies. The findings reveal that:

- 18 per cent of respondents reported a value added per employee in the range of 100,000 € - 200,000 €.
- 14 per cent fell within the 200,000 € - 500,000 € range.
- Three categories (less than 15,000 €; 40,000 € - 60,000 €; 60,000 € - 100,000 €) each represent 13 per cent of the respondents.
- Nine per cent of respondents reported values ranging from 15,000 € - 25,000 €.
- The categories of 25,000 € - 40,000 € and more than 500,000 € each accounted for 3 per cent of respondents.

Table 7: Approximate value added per employee, in % of all respondents

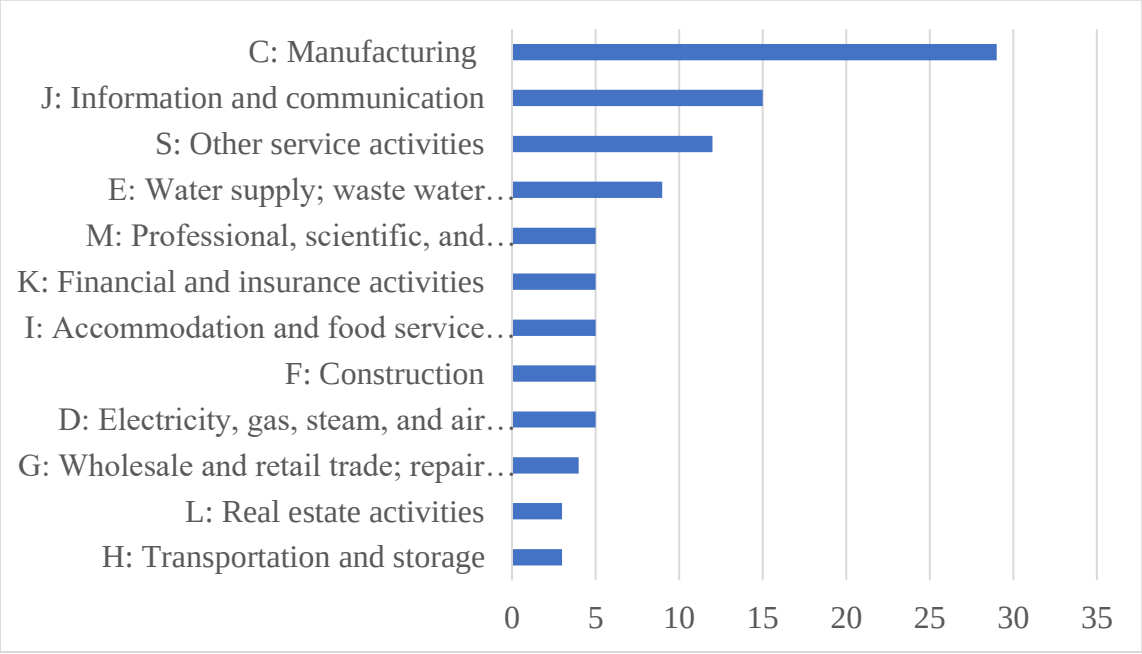
	Per cent
Less than 15,000 €	13.0
15,000 € - 25,000 €	9.0
100,000 € - 200,000 €	18.0
200,000 € - 500,000 €	14.0
25,000 € - 40,000 €	3.0
40,000 € - 60,000 €	13.0
60,000 € - 100,000 €	13.0
More than 500 000 €	3.0

Source: Own work.

Furthermore, the mean tenure of employees in their current companies is 7.36 years, with a median of 6 years. The standard deviation stands at 4.63 years, indicating some variability in employee tenure, ranging from a minimum of 1 year to a maximum of 27 years.

When it comes to division by company sector, Figure 20 shows that most respondents work in the manufacturing industry, 29 per cent, followed by information and communication, 15 per cent, and other service activities, 12 per cent. The sectors with the lowest representation are transportation and storage, as well as real estate activities, both accounting for 3 per cent of respondents. It is worth mentioning that administrative and support service activities as well as education had no responses in this survey.

Figure 20: Number of respondents by company sector in Serbia, in % of all respondents

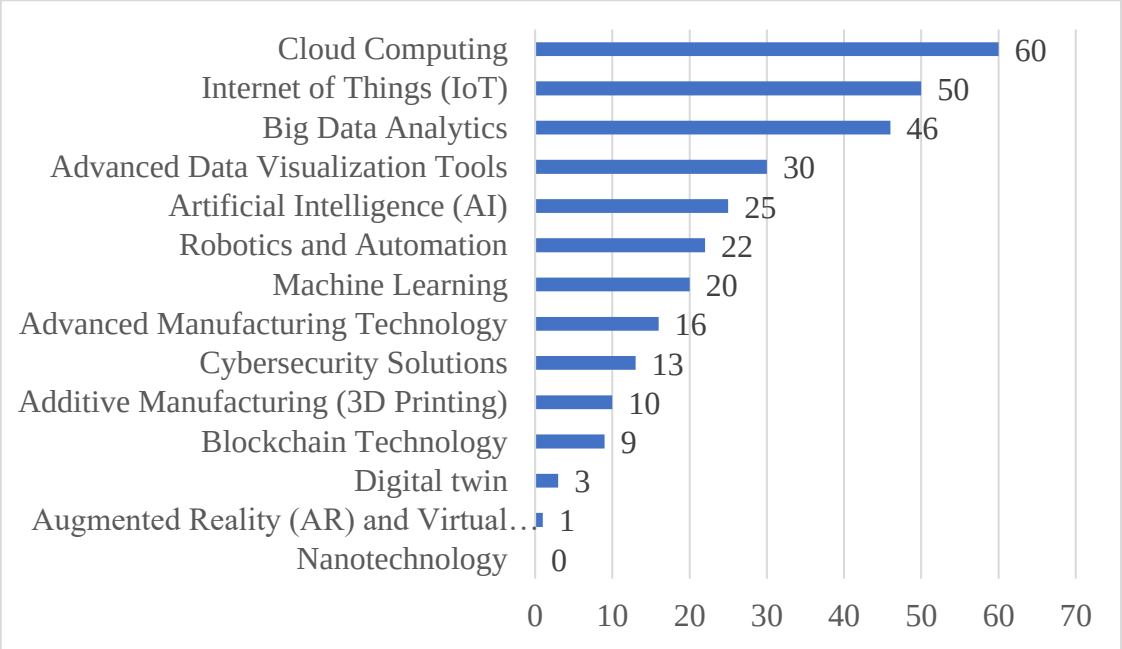


Source: Own work.

4.4 Current Adoption of Advanced Technologies, Business Software and Strategies in Surveyed Organizations

Figure 21 shows what advanced technologies are currently implemented in organizations in Serbia. It is evident that cloud computing is currently the most popular and widely adopted advanced technology. We can also observe that there is a significant gap between the implementation of the first three technologies compared to other advanced technologies. The low adoption of the last three technologies may suggest that these technologies could still be in the early stages of adoption or may not be considered a priority for the surveyed organizations. This could be due to various factors such as cost, complexity, or lack of awareness about its potential benefits.

Figure 21: Distribution of advanced technology adoption in organizations in Serbia, in % of all respondents



Note: Respondents were allowed to select multiple technologies
Source: Own work.

On average, organizations in Serbia adopt five technologies. This allows us to categorize companies into two groups: those with a higher level of digitalisation, having implemented five or more technologies, and those with a lower level of digitalisation, incorporating less than five technologies, as illustrated in Table 8.

Analysis outlines that 65 per cent of organisations have a higher level of digitalisation, while 35 per cent of them have a lower level of digitalisation. When considering the number of employees, the data reveals that among companies implementing five or more advanced technologies, the majority, constituting 54 per cent, are large organizations with 250+ employees. In contrast, among companies implementing less than five technologies, 48 per cent are those with 10-49 employees.

Question 2 specifically focused on the business software employed within these enterprises. Participants were presented with a multiple-choice question where they were asked to indicate which software their organization utilizes. The options provided were Enterprise Resource Planning (ERP) software, Customer Relationship Management (CRM) software, and Business Intelligence (BI) software.

Upon analysing the responses, as demonstrated in Table 8, it was observed that most companies (36 of them) are employing all three software options. Additionally, 16 companies indicated that they utilize both ERP and BI software. These findings highlight the widespread adoption of these advanced technologies within the surveyed organizations.

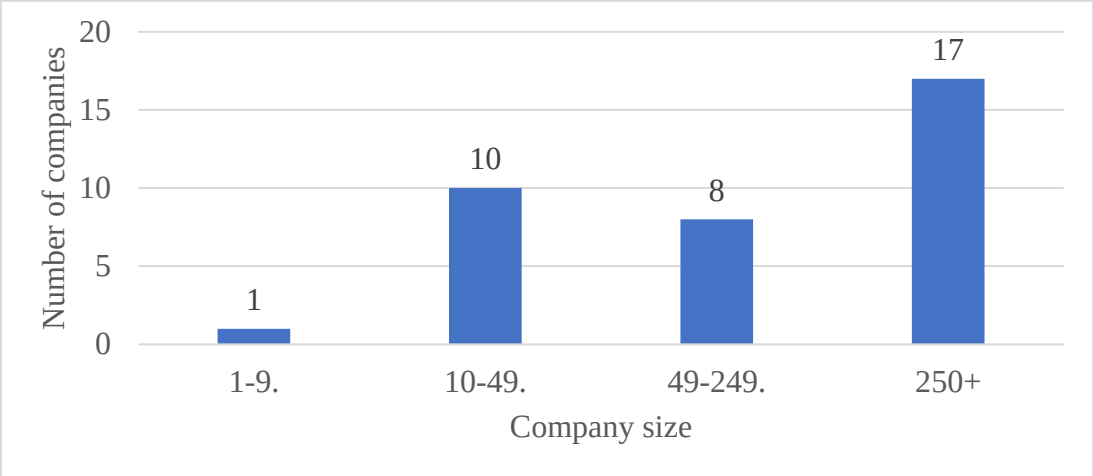
Table 8: Specific combination of business software currently used within respondent's organization in Serbia, in % of all respondents

Business software	Percentage distribution of companies
BI, CRM	1
CRM	4
ERP	8
BI	12
CRM, BI	15
ERP, BI	16
ERP, CRM, BI	36

Source: Own work.

Figure 22 shows that out of the 36 companies that have implemented all three software options, the highest number of them (17) have over 250 employees.

Figure 22: Size of companies which implemented all three software options (ERP, CRM, BI), in %



Source: Own work.

Table 9 demonstrates to what extent the company's existing strategy addresses digitalisation and Industry 4.0. Responses indicate that a significant number of companies (23) do not mention digitalisation and Industry 4.0 in their strategies. However, there are companies that have started incorporating digitalisation and Industry 4.0 in their strategies, with 14 companies mentioning it but not having a separate strategy, 15 companies implementing pilot projects, and 16 companies having a separate digitalisation strategy in progress. On the other hand, a notable number of companies (32) have fully encompassed digitalisation and Industry 4.0 in their strategies. This information highlights the varying levels of commitment and progress towards digitalisation and Industry 4.0 among surveyed organizations.

Table 9: Extent of company's strategy on digitalisation and Industry 4.0 in Serbia, in % of all respondents

Strategy	Percentage distribution of companies
Digitalisation and Industry 4.0 are mentioned in our strategy, but we do not have a separate digitalisation strategy.	14
We are implementing pilot projects related to digitalisation and Industry 4.0.	15
We have a separate digitalisation strategy in progress.	16
Digitalisation and Industry 4.0 are not mentioned in our strategies.	23
Our strategy fully encompasses digitalisation and Industry 4.0.	32

Source: Own work.

The analysis of the connection between strategies and company sizes reveals that smaller companies, with 1-9 employees and 10-49 employees, have not yet fully embraced digitalisation and Industry 4.0 in their strategies. On the other hand, medium-sized companies with 50-249 employees, as well as larger companies with 250+ employees, have made more progress in incorporating these concepts into their strategies. Specifically, for companies with 1-9 employees, 7 of them mentioned that digitalisation and Industry 4.0 are not mentioned in their strategies. Similarly, for companies with 10-49 employees, 13 of them do not mention these concepts in their strategies. However, for medium-sized companies with 50-249 employees, 7 companies stated that their strategy fully encompasses digitalisation and Industry 4.0. For larger companies with 250+ employees, 20 companies mentioned that their strategy fully encompasses these concepts. Overall, the findings suggest that there is a correlation between company size and the extent of digitalisation and Industry 4.0 strategies. The responses from larger companies drive the general findings for this question, indicating a greater level of commitment and progress in their strategies compared to smaller companies.

Furthermore, analysis, categorizing organizations into lower and higher digitalised groups, reveals that a significant proportion of companies fully incorporating digitalisation and Industry 4.0 into their strategies belong to the higher digitalised category. Specifically, out

of the total 32 per cent of companies embracing digitalisation and Industry 4.0, a substantial 23 per cent originate from the higher digitalised category. Conversely, findings indicate that companies without explicit mentions of digitalisation and Industry 4.0 in their strategies predominantly come from lower digitalised organizations, constituting 16 per cent of the total 23 per cent.

4.5 Importance of Factors for Industry 4.0 Implementation

In Question 4 survey respondents rated the importance of different factors for Industry 4.0 implementation on a scale from 1 (not important at all) to 5 (very important). This question helps us understand the motivations and priorities of companies when it comes to implementing Industry 4.0 technologies. Respondents considered "Gaining a competitive advantage" and "Enhancing safety and risk management" to be the most important factors for implementing Industry 4.0. By knowing that these factors are considered most important, companies can prioritize their efforts and investments accordingly.

On the other hand, respondents found "Enabling data-driven decision-making" to be the least important on average. Understanding factors that are considered least important can also provide valuable insights into areas that may need further development or improvement.

Table 10: Importance of factors, 1 (not important at all) to 5 (very important), for Industry 4.0 implementation in companies

	Mean	Median	Std. Deviation
Enhancing operational efficiency	3.41	3.00	1.30
Increased quality and reliability of products and services	3.61	4.00	1.21
Increasing productivity	3.65	4.00	1.22
Enabling data-driven decision-making	3.68	4.00	1.25
Enabling predictive maintenance and reducing downtime	3.53	4.00	1.23
Greater flexibility and agility in operations	3.59	4.00	1.27
Gaining a competitive advantage	3.78	4.00	1.15
Better horizontal/vertical integration	3.49	4.00	1.26
Enhancing safety and risk management	3.78	4.00	1.13
Meeting customer demands and expectations	3.43	3.00	1.23
Addressing workforce challenges (e.g., labor shortages, skill gaps)	3.52	4.00	1.22

Source: Own work.

Furthermore, the analysis indicates a distinct pattern in the priorities of companies based on their sizes. Notably, larger companies with 250+ employees prioritize “Enabling data-driven decision-making” as the most crucial factor. In contrast, medium-sized companies with 50-249 employees place a higher emphasis on “Increasing productivity”. Smaller companies with 10-49 and 1-9 employees tend to consider “Gaining a competitive advantage” as their primary factor of significance. This observation highlights how businesses across different scales tailor their strategic priorities, reflecting the diversity in strategic focus within different business sizes.

Additionally, when analysing the priorities withing different sectors it is evident that companies in manufacturing sector tend to prioritize “Increasing productivity” and “Better horizontal/vertical integration” over other factors. Meanwile, organizations in service oriented industries tend to prioritize “Gaining a competitive advantage” and “Increased quality and reliability of products and services”.

Overall, by understanding these factors and prioritizing them in their Industry 4.0 implementation strategies, companies can gain a competitive advantage, optimize their operations, and thrive in the digital age.

4.6 Managerial Views on Industry 4.0 Implementation

In Question 5 survey respondents rated attitudes of company managers towards the implementation of Industry 4.0. Participants rated various aspects on a scale ranging from 1 (very negative) to 5 (very positive). By knowing their views, companies can identify potential barriers and opportunities for successful implementation. Additionally, understanding the levels of acceptance and readiness of managers can inform decision-making and help companies develop effective strategies for implementing Industry 4.0 technologies.

As shown in Table 11, on average, respondents indicated the “Willingness to experiment and embrace innovation in the organization” and “IT and other departments strongly cooperate in implementation” to be the most frequent attitudes of company managers towards the implementation of Industry 4.0. These findings can suggest that companies are open to change and collaboration, which are very important for successful implementation of Industry 4.0 technologies.

In contrast, the attribute that received the lowest average rating was “Clear communication of Industry 4.0 goals and objectives throughout the organization”. The lowest rating suggests that there may be a lack of understanding and alignment within the organization, which can hinder effective implementation.

Table 11: Attitudes of company managers, 1 (very negative) to 5 (very positive), towards the implementation of Industry 4.0

	Mean	Median	Std. Deviation
Management had dedicated a digital budget	2.74	3.00	1.24
Management actively promotes and supports Industry 4.0 initiatives	2.79	3.00	1.24
Clear communication of Industry 4.0 goals and objectives throughout the organization	2.60	2.00	1.24
Allocation of dedicated resources and budget for Industry 4.0 implementation	2.87	3.00	1.24
Emphasis on continuous learning and upskilling of employees for Industry 4.0	2.79	3.00	1.17
Proactive approach to identifying and adopting emerging technologies	2.92	3.00	1.24
Regular monitoring and evaluation of Industry 4.0 progress and outcomes	2.83	3.00	1.26
Alignment of Industry 4.0 initiatives with the overall business strategy	2.86	3.00	1.21
Willingness to experiment and embrace innovation in the organization	2.94	3.00	1.23
IT and other departments strongly cooperate in planning	2.92	3.00	1.24
IT and other departments strongly cooperate in implementation	2.94	3.00	1.34
Encouragement of cross-functional collaboration and knowledge sharing	2.77	3.00	1.16

Source: Own work.

Examining management attitudes towards technology implementation by company size reveals interesting insights. In small companies with 1-10 employees, the highest mean is found in "Willingness to experiment and embrace innovation in the organization", indicating a tendency for smaller entities to possess greater flexibility and openness to experimentation. This may suggest that smaller organizations are more agile, allowing them to readily embrace innovation.

For companies within the 10-49 employee bracket, while the top score shows "Proactive approach to identifying and adopting emerging technologies", the median score for this group of 2.58 hints at a potential need for a more comprehensive adoption strategy. This midpoint score could suggest that there might be a lack of consensus or consistent alignment within this particular company size group regarding the significance of these technological

strategies. The relatively average score, when compared to other company sizes, might point to a need for greater clarity, a more unified strategy, or possibly a more comprehensive understanding and commitment towards adopting emerging technologies in this specific

In medium-sized organizations with 50-249 employees, the focus on "Allocation of dedicated resources and budget for Industry 4.0 implementation" indicates a firm commitment to invest in the necessary resources for technological advancements. This reflects an understanding that proper resourcing is a vital aspect of successful technology integration and development.

In large companies of 250+ employees, the highest score emerges in "IT and other departments strongly cooperate in implementation". This could suggest that collaboration and alignment across different divisions within larger organizations are pivotal in achieving successful and harmonious implementation of Industry 4.0 technologies.

Furthermore, among higher digitalised companies, the top score is for "IT and other departments strongly cooperate in both planning and implementation." In contrast, for lower digitalised companies, the emphasis is on "Willingness to experiment and embrace innovation in the organization."

By identifying the areas that require improvement, companies can focus on developing effective communication strategies that clearly articulate the goals and objectives of the Industry 4.0 implementation. By fostering a culture of innovation and collaboration and ensuring that all employees understand the purpose and potential benefits of the implementation, companies can successfully adopt and leverage Industry 4.0 technologies. Overall, this information can provide valuable insights for companies seeking to optimize their Industry 4.0 implementation strategies.

4.7 Impact on Decision-Making Processes and Strategy

In Question 6, survey respondents rated to what extent has the adoption of Industry 4.0 technologies influenced decision-making processes and strategic planning in their companies. Survey participants provided ratings on a scale from 1 (very minimal) to 5 (significant). Understanding the extent to which the adoption of Industry 4.0 technologies has influenced decision-making processes and strategic planning can help in identify the areas within a company that have been most impacted by these technologies. For example, from Table 12 we can learn that the area most significantly impacted is "Supply chain optimization and logistics planning", this knowledge allows managers to allocate resources and investments accordingly to maximize the benefits and address any challenges or gaps in implementation.

Table 12: Impact on decision-making processes and strategic planning in companies, 1 (very minimal) to 5 (significant)

	Mean	Median	Std. Deviation
Resource allocation and investment decisions	2.72	3.00	1.311
Supply chain optimization and logistics planning	3.09	3.00	1.371
Market analysis	3.08	3.00	1.338
Customer segmentation	2.92	3.00	1.292
Risk assessment and mitigation strategies	2.81	3.00	1.220
Sustainability and environmental impact considerations	3.00	3.00	1.414
Branding and marketing strategies	2.99	3.00	1.389
Expansion and market entry strategies	3.06	3.00	1.293
Product portfolio management and diversification strategies	2.98	3.00	1.341

Source: Own work.

When examining responses based on company size, it becomes evident that smaller companies with 1-9 employees are significantly impacted by "Branding and marketing strategies", showcasing a robust median of 4.38. This substantial rating might imply that smaller entities are keen on establishing their brand, perhaps reflecting their newer presence in the market and their eagerness to gain recognition and visibility.

For companies with 10-49 employees, the top score is allocated to "Supply chain optimization and logistics planning". This emphasis could potentially suggest a strategic focus on operational efficiency, implying a need to streamline and enhance their logistical procedures for increased efficacy and productivity.

Within medium-sized companies with 50-249 employees, the most prominent score goes to "Sustainability and environmental impact considerations" This emphasis might imply a corporate priority for environmental responsibility and ethical practices, suggesting a keen interest in aligning operations with sustainability principles.

For larger companies with 250+ employees, the highest scores applies to "Supply chain optimization and logistics planning" and "Expansion and market entry strategies". This dual focus could suggest a balanced priority for both enhancing operational efficiency and expanding market reach. It might indicate a concerted effort to fortify internal operations while concurrently exploring opportunities for growth and market penetration.

Knowing the impact on decision making processes and strategy also provides valuable insights into the overall effectiveness of these technologies within the organization. It allows managers to assess whether the adoption has been successful and if further improvements or

adjustments are necessary. Furthermore, this information can be used for benchmarking purposes, comparing the company's performance and level of adoption to industry peers. It provides a basis for evaluating competitiveness and identifying areas where the company may be lagging or excelling in relation to others.

4.8 Challenges in Industry 4.0 Adoption

In Question 7, survey respondents rated the main obstacles and challenges their company encountered during the implementation of Industry 4.0 technologies. Participants provided ratings on a scale from 1 (minor challenge) to 5 (major challenge). Understanding the main obstacles and challenges is important for identifying potential roadblocks and developing strategies to overcome them. By rating these challenges, organizations can prioritize their efforts and allocate resources effectively, the most significant challenge reported was "Difficulty in identifying suitable technology solutions for specific business needs", while the least challenging aspect was "Supplier or partner readiness and compatibility".

Table 13: Obstacles and challenges encountered during the implementation of Industry 4.0 technologies, 1 (minor challenge) to 5 (major challenge)

	Mean	Median	Std. Deviation
Lack of skilled workforce	3.51	3.50	1.17
High implementation costs	3.08	3.00	1.30
Resistance to change among employees	3.26	3.00	1.26
Data privacy concerns	2.73	3.00	1.16
Lack of technical support and expertise	3.39	3.00	1.19
Limited access to advanced technology infrastructure	3.18	3.00	1.37
Difficulty in identifying suitable technology solutions for specific business needs	3.67	4.00	1.07
Regulatory or compliance issues	2.33	2.00	1.07
Uncertain return on investment (ROI)	3.15	3.00	1.16
Supplier or partner readiness and compatibility	2.23	2.00	1.13
Lack of awareness or understanding of Industry 4.0 concepts	3.34	3.00	1.24

Source: Own work.

Categorizing organizations into lower and higher digitalised groups, reveals that higher digitalised companies recognize "Difficulty in identifying suitable technology solutions for specific business needs" (mean 3.8). while lower digitalised see "Lack of technical support and expertise".

Upon categorizing organizations into lower and higher digitalised groups, it is evident that higher digitalised companies recognize the "Difficulty in identifying suitable technology

solutions for specific business needs" as their main challenge, with an average rating of 3.8. This indicates their awareness of the complexities involved in selecting the right technology solutions that align with their specific requirements and goals. By acknowledging this challenge, higher digitalized companies may be better prepared to address it and find suitable solutions that can drive their digital transformation journey.

On the other hand, lower digitalised companies perceive the "Lack of technical support and expertise" as their major obstacle. This may highlight their need for external assistance and guidance in implementing Industry 4.0 technologies. Lower digitalised companies may possibly lack the necessary in-house expertise and resources to navigate the complexities of digital transformation. By recognizing this challenge, these companies can seek partnerships or collaborations with external partners to bridge the gaps in technical support and expertise.

By understanding and addressing these challenges, companies can overcome barriers and fully leverage the potential benefits of advanced technologies. This will enable them to drive their digital transformation journey and gain a competitive advantage in the evolving business landscape.

4.9 Stakeholder Perspectives, Subsidies and Competition in Industry 4.0

In Question 8 respondents were asked to rate collaborators' importance in relation to the actual implementation of Industry 4.0 initiatives. As presented in Table 14 among the factors evaluated, "External partners" received the highest average rating, indicating a strong consensus among respondents regarding their significance. Conversely, "Research institutions" were rated as the least important collaborator group, suggesting greater variation in opinions among respondents regarding their importance in the context of Industry 4.0 implementation.

Table 14: Collaborators' importance in relation to the implementation of Industry 4.0

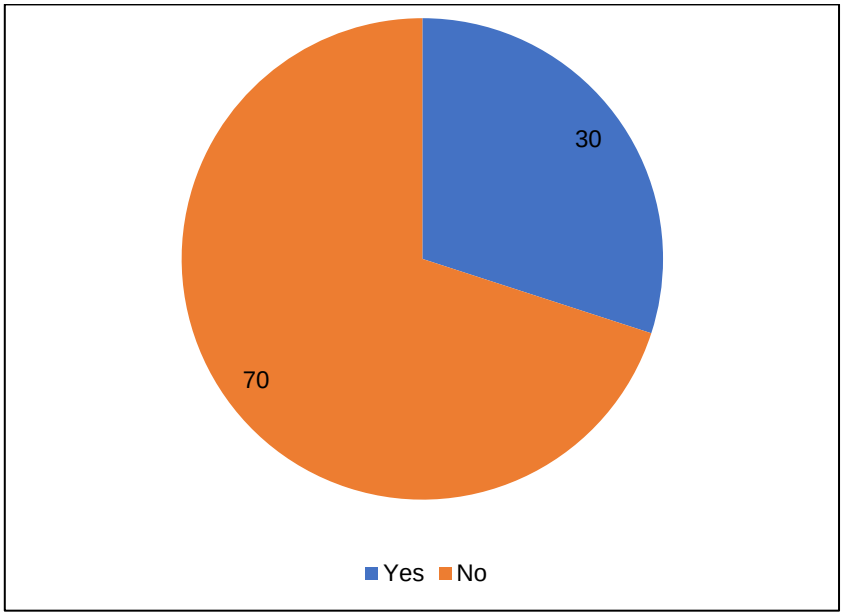
	Mean	Median	Std. Deviation
Chamber of commerce	2.55	3.00	1.04
Government agencies	2.40	2.00	1.12
External partners	4.11	4.00	1.02
Funding programs	3.78	4.00	1.19
Industry associations	3.78	4.00	1.20
Universities	2.58	3.00	1.10
Research institutions	2.54	2.00	1.07
Consulting firms	3.67	4.00	1.04
International organizations or agencies	3.21	3.00	1.34

Source: Own work.

Knowing which partners are important for companies is crucial for their decision-making process when forming collaborations. It provides companies with valuable information on potential partners that they should prioritize and seek for collaboration in their Industry 4.0 implementation efforts. Furthermore, it serves as a guide for companies that have not yet started any collaborations, giving them a heads-up on the importance of forming partnerships for successful Industry 4.0 implementation.

In response to Q9, which asked, "Have you utilized any state subsidies or EU subsidies to facilitate the financing of your Industry 4.0 technology implementation?" the majority of respondents, specifically 70 per cent of them, indicated that their companies have not utilized state subsidies or EU subsidies to assist in financing the implementation of Industry 4.0 technology.

Figure 23: Have you utilized any state subsidies or EU subsidies to facilitate the financing of your Industry 4.0 technology implementation in per cent



Source: Own work.

Respondents were, also, provided with the opportunity to provide specific details regarding their answers. Although the majority of participants stated that they hadn't used any subsidies, their responses offered valuable insights.

- Awareness of partner utilising respondents indicated that, although they themselves had not utilized subsidies, they were aware of some of their partners who had taken advantage of these financial incentives.
- Future considerations: some respondents, who had not utilized subsidies at the time of the survey, expressed an openness to exploring this option in the future. They considered subsidies as a potential component of their strategic approach to the implementation of Industry 4.0 technologies.

For those respondents who confirmed their utilization of state subsidies or EU subsidies to support their Industry 4.0 technology implementation, their responses highlighted several key themes:

- Support for innovative business development: respondents mentioned accessing subsidies aimed at fostering the growth and development of innovative businesses, which facilitated their Industry 4.0 initiatives.
- EU subsidies for Industry 4.0 development: some respondents explicitly stated that they had leveraged EU subsidies specifically designated for the advancement of Industry 4.0 technologies.
- Involvement of the European Investment Bank (EIB): the involvement of the European Investment Bank (EIB) was indicated, likely indicating financial support or loans from this institution.
- Emphasis on energy efficiency: a subset of respondents referenced subsidies related to energy efficiency, demonstrating a commitment to sustainable and energy-efficient Industry 4.0 implementations.
- Facilitating innovation: subsidies were acknowledged as instrumental in facilitating innovation and development within the context of Industry 4.0.
- Accessing development funds: the utilization of development funds was also mentioned, signifying financial support for business growth and technological advancement.
- Support for IoT technology development: subsidies dedicated to the development of IoT technologies were cited, emphasizing their role in enabling Industry 4.0 implementations.

In summary, while most respondents had not utilized state or EU subsidies for their Industry 4.0 technology implementation, those who had done so highlighted various ways in which these subsidies supported their initiatives, particularly in terms of fostering innovation, enhancing competitiveness, and promoting sustainability.

4.10 Comparative Company Performance

In Q10 respondents were asked to rate their company's overall performance compared to other companies in their industry on a scale from 1 (significantly worse) to 5 (significantly better). As shown in Table 15 most respondents, viewed “The quality of their products or services” as a notable strength, positioning their company favourably within the industry. Conversely, the area of "Inventory Turnover" received the lowest average rating, suggesting that respondents perceived this aspect of their company's performance as relatively weaker when compared to others in the industry.

Table 15: Overall performance of companies compared to competitors in their industry, 1 (significantly worse) to 5 (significantly better)

	Mean	Median	Std. Deviation
Revenue Growth	3.13	3.00	1.40
Profit Margin	2.95	3.00	1.43
Return on Investment	3.07	3.00	1.36
Return on Asset	2.98	3.00	1.36
Productivity	3.20	3.00	1.19
Market Share	3.00	3.00	1.18
Cost Reduction	2.86	3.00	1.12
Inventory Turnover	2.41	2.00	1.17
Supply Chain Efficiency	2.56	3.00	1.04
Customer Acquisition and Retention	3.79	4.00	0.90
Product/service quality	3.80	4.00	0.91
Product/service performance	3.76	4.00	0.93
Employee Engagement and Satisfaction	3.64	4.00	0.96
Innovation and New Product Development	3.11	3.00	1.49
Overall Performance Improvements	3.13	3.00	1.38

Source: Own work.

Upon reviewing the ratings categorized by company size, it's notable that companies with 1-10 employees perceive “Market Share” as their greatest strength. This emphasis may indicate a strong drive to establish a notable position in the market, potentially striving for recognition and market presence.

For companies with 10-49 employees, “Customer Acquisition and Retention” emerge as the strongest point, reflecting a strategic approach towards growing their customer base while retaining existing clients. The emphasis on these factors likely highlights their significance in sustaining and expanding the business.

In medium-sized companies with 50-249 employees, there is a dual emphasis on “Product/service quality” and “Product/service performance.” This significant focus may signify a strong dedication to ensuring not only high-quality offerings but also consistent performance, demonstrating a commitment to sustaining and enhancing their product or service standards.

Within larger companies with 250+ employees, the dual attention is on “Product/service quality” and “Employee Engagement and Satisfaction.” This focus may indicate a balanced concern for delivering high-quality products or services while also prioritizing a work environment that fosters employee contentment and engagement.

Upon analysing the responses by sector, it becomes apparent that the manufacturing sector places a strong emphasis on “Product/service quality.” This emphasis may suggest a focus on the production or delivery of superior products or services, a key attribute for manufacturers to maintain a competitive edge and ensure customer satisfaction.

In contrast, companies operating within service-oriented industries exhibit a different emphasis, with “Customer Acquisition and Retention” as their primary strength. This priority highlights the importance of continuously acquiring new customers while also focusing on retaining the existing customer base in order to sustain business growth and profitability.

Additionally, for higher digitalised companies two factors stand out, Product/service quality and product/service performance. For lower digitalised companies it is Customer Acquisition and Retention

Additionally, it is evident that higher digitalised companies place a strong emphasis on “Product/service quality” and “Product/service performance”. This focus indicates their commitment to delivering superior products or services that meet the highest standards of quality and performance. On the other hand, lower digitalised companies prioritize “Customer Acquisition and Retention”. This emphasis highlights their strategic approach to growing their customer base and ensuring customer loyalty.

The difference in priorities between higher and lower digitalised companies can be attributed to their varying levels of technological adoption and capabilities. Higher digitalised companies, with their better understanding, or ability for implementation of technology solutions, can focus on enhancing product or service quality and performance. This is made possible by leveraging advanced technologies and digital tools to optimize their operations and deliver exceptional offerings.

In contrast, lower digitalized companies may face challenges in implementing Industry 4.0 technologies or the lack of necessary technical support and expertise. As a result, they prioritize customer acquisition and retention to drive growth and sustain their business. These companies recognize the importance of building strong relationships with customers and delivering value to ensure their growth.

By analysing the ratings, companies can identify their strengths and weaknesses in relation to their competitors. This understanding allows them to make targeted improvements and strategic decisions to enhance their overall performance.

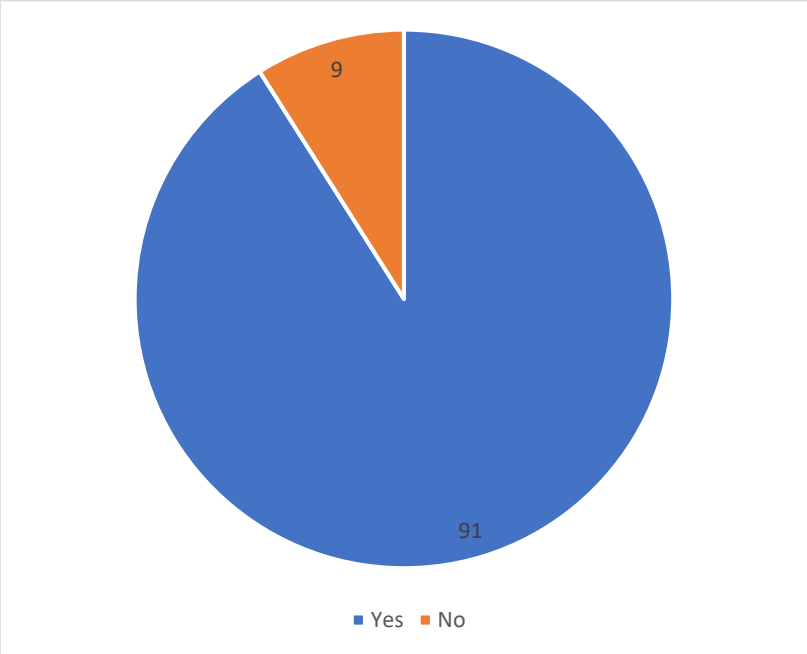
Additionally, it provides a benchmark for companies to measure their progress and track their competitiveness over time. This analysis can be a valuable tool for organizations looking to stay ahead of the competition.

4.11 Realizing the benefits of implementing Industry 4.0 technologies

Respondents who have adopted at least one Industry 4.0 technology in Question 11 were asked to rate the benefits or improvements they have observed as a result of implementing these technologies. They provided their ratings on a scale from 1 (No visible benefits or improvements) to 5 (Significant benefits or improvements).

Figure 24 shows that 91 per cent of respondents have implemented at least one Industry 4.0 technology.

Figure 24: Companies that adopted at least one industry 4.0 technology, in % of all companies



Source: Own work.

Table 16 shows how respondents ranked the factors. Factors such as “Improved competitiveness” and “Increased operational efficiency” have both higher mean ratings and lower standard deviation values, suggesting that respondents generally agree on the positive impact of these factors. On the other hand, factors like “Improved innovation” and “Product and service customization” have lower mean ratings and higher standard deviation values, indicating that there is more variability in respondents' perceptions regarding the benefits of these factors.

Table 16: Benefits if your company adopted at least one Industry 4.0 technology

	Mean	Median	Std. Deviation
Increased operational efficiency	3.48	3.00	1.09
Improved product quality	3.42	3.00	1.21
Enhanced decision-making capabilities	3.47	4.00	1.17
Cost reduction	3.38	3.00	1.15
Development of new products and services	3.36	3.00	1.15
Product and service customization	3.14	3.00	1.22
Improved customer satisfaction	3.37	3.00	1.19
Improved competitiveness	3.57	4.00	1.05
Process improvement	3.47	4.00	1.22
Improved innovation	3.43	3.00	1.27
Enhanced value added	3.33	3.00	1.11
Enhanced supply chain management	3.23	3.00	1.16
Greater operational flexibility	3.30	3.00	1.15
Increased data security	3.41	3.00	1.20
Better overall performance	3.25	3.00	1.17
Less human errors due to process automatization	3.51	4.00	1.15

Source: Own work.

This information can be used to prioritize and allocate resources towards the factors that are perceived to have the greatest impact and consensus among respondents. It can also highlight areas where further investigation and improvement may be needed to address varying perceptions and enhance the overall benefits of Industry 4.0 technologies in organizations.

Furthermore, as shown in Table 17 based on the analysis of the benefits by company size, it can be observed that smaller companies with 1-9 employees prioritize factors such as “Cost reduction” and have lower ratings for “Product and service customization”. This suggests that cost reduction is seen as a key benefit for smaller organizations, while customization may be less important.

For companies with 10-49 employees, the highest-rated factor is “Enhanced decision-making capabilities”, indicating that these organizations value the improvement in decision-making that comes with Industry 4.0 technologies. On the other hand, “Enhanced supply chain management” has the lowest rating, indicating that these companies may not see as much value in this aspect.

In companies with 50-249 employees, the factor with the highest rating is “Less human errors”, suggesting that these organizations prioritize reducing errors through automation. Meanwhile, “Product and service customization” has the lowest rating, like the previous company size category.

For larger companies with 250+ employees, “Process improvement” is the highest-rated factor, indicating a focus on streamlining and optimizing processes. The lowest-rated factor is again “Product and service customization”, suggesting that customization may not be a priority for these larger organizations. For companies with 50-249 employees and 250+ employees, it is also observed that there are no significant differences in the average ratings of different factors.

Table 17: Analysis of the benefits by company size

Number of employees	Highest factor	Rating	Lowest factor	Rating
01-09	Cost reduction	4.57	Product and service customization	3.14
10-49	Enhanced decision-making capabilities	3.94	Enhanced supply chain management	2.47
50-249	Less human errors	3.76	Product and service customization	2.88
250+	Process improvement	3.61	Product and service customization	3.06

Source: Own work.

Additionally, when analysing organisations based on digitalisation level it is evident that the higher digitalised companies see the biggest benefit with “Improved competitiveness”. These companies are leveraging advanced technologies which provide them a competitive edge. On the other hand, the lower digitalised companies prioritize “Improved product quality" as their biggest benefit. This suggests that these organizations perceive Industry 4.0 technologies as a means to improve their products and services. By implementing advanced technologies, these companies aim to enhance the quality and reliability of their offerings, which can help them gain a competitive advantage in their respective markets.

These findings highlight the varying priorities and perceptions of different company sizes and companies with different digitalisation levels when it comes to the benefits of Industry 4.0 technologies. Understanding these differences can help organizations tailor their implementation strategies and allocate resources effectively.

4.12 Hypothesis Testing

In the dynamic landscape of Industry 4.0, where technological evolution unfolds at an unprecedented pace there is a crucial need to ensure that the changes being implemented are not only beneficial but statistically significant. This is where hypothesis testing comes into play. This chapter delves into the core of hypothesis testing within the Industry 4.0 landscape, exploring its significance, methodologies, and practical applications.

4.12.1 H1: The COVID-19 pandemic may have influenced organizations' motivations for adopting Industry 4.0 technologies.

I examined the hypothesis using descriptive statistics and conducted a Chi-squared test of equal probabilities. The findings indicate that the majority of respondents, 55 per cent, believe that the COVID-19 pandemic did not influence the motives for implementing Industry 4.0 in their organization. Furthermore, the result of the Chi-squared test (Chi-squared=0.887; P=0.317) suggests that there are no statistically significant differences among the respondents regarding whether the COVID-19 pandemic impacted the motives for implementing Industry 4.0 in their organization.

Table 18: Descriptive statistics and Chi-squared test

	Per cent	Chi-Square	Sig
Yes	45.0	0.887	0.317
No	55.0		

Source: Own work.

We do not accept hypothesis H1.

4.13 Research Limitations

In any research endeavour, it's essential to recognize the limitations that may have influenced the study's outcomes. This investigation into the adoption of Industry 4.0 in Serbian companies has provided valuable insights; however, it is not without its constraints.

Firstly, the sample size and its representativeness must be acknowledged as a potential limitation. While responses were collected from a substantial number of participants (n=100), the extent to which this sample is truly representative of the diverse landscape of Serbian companies, spanning various industries and sizes, remains a concern. This could affect the broader applicability of the findings.

Moreover, the sampling method employed, which primarily leveraged LinkedIn, private messages, and email outreach to executives, could introduce a degree of selection bias. Respondents who opted to participate might not fully mirror the attitudes and practices of the entire business community in Serbia, potentially skewing the results.

Furthermore, it's essential to consider that respondents from larger companies may provide insights based on their specific department or role within the organization. In larger enterprises, the implementation of Industry 4.0 technologies can vary widely across different divisions or units. Therefore, the responses collected from individuals within these organizations may not fully capture the holistic perspective of the entire company. This limitation underscores the complexity of understanding the nuanced dynamics of Industry 4.0 adoption within large, multifaceted enterprises.

Another potential limitation relates to the possibility of multiple respondents from the same company participating in the survey. While efforts were made to prevent duplicate responses, it is challenging to eliminate this possibility, especially in cases where multiple executives or employees from a single company may independently complete the survey. This could potentially introduce redundancy in the data and result in a skewed representation of the company's views. It's important to acknowledge this limitation when interpreting the findings, as multiple responses from the same organization may inadvertently reinforce certain perspectives or biases.

Despite these limitations, this research serves as a valuable contribution to the understanding of Industry 4.0 adoption in Serbian companies. It offers a comprehensive overview of current practices, challenges, and opportunities, shedding light on a topic that is of increasing importance in today's global business landscape. These limitations should be viewed as opportunities for future research to build upon this foundation and provide a more comprehensive understanding of Industry 4.0 adoption in Serbian companies. They do not diminish the significance of the insights gained but underscore the need for cautious interpretation and a broader research agenda in this evolving field.

5 RECOMMENDATIONS

Building on the empirical insights gained, a set of strategic recommendations has been created. These recommendations are aimed at accelerating the implementation of Industry 4.0 for the benefit of Serbian businesses. They include a variety of areas such as investment strategies, educational initiatives, workforce development, the role of government policies and national Industry 4.0 strategies. These recommendations collectively form a robust framework for advancing Industry 4.0 in Serbia, aligning it effectively with empirical research findings and the current business landscape.

5.1 Investment Strategies

As outlined in Chapter 3.1.3, in Serbia, the investment landscape presents a challenge due to limited total investments, stemming primarily from low public and domestic private investment. Low public investments are driven by myopic fiscal policies prioritizing short-term political support over long-term economic growth, coupled with inefficient state investment project planning. On the private investment front, low levels are linked to factors like return on investment and investment risk, although favourable fiscal conditions exist in Serbia. The core issue seems to be a lack of domestic savings, driven by long-standing income policy issues and an underdeveloped financial system.

To boost domestic and private investments in Serbia, a multifaceted approach is needed. Serbia must undertake substantial reforms aimed at improving the ease of doing business, ensuring legal predictability, and reducing bureaucratic complexities. Investment in

infrastructure development and the creation of a stable economic and political environment is paramount. A re-evaluation of income policies to encourage balanced income and investment growth is necessary. Serbia should also work towards enhancing the domestic financial system to offer a wider range of savings instruments, thus promoting higher savings rates among citizens. Macroeconomic stability must be preserved to establish an attractive investment climate. Additionally, streamlining and simplifying policies, while reducing bureaucratic constraints, is crucial to improving conditions for both domestic and private investments.

Serbia should transition from attracting Foreign Direct Investment (FDI) primarily to address unemployment rates to a more sophisticated focus on value-added investments. Here regions in closer proximity to major cities like Belgrade and Novi Sad have been shifting towards this second phase, largely due to attributes like a young and educated population, well-developed infrastructure, and proximity to the European market. To propel the manufacturing sector, Serbia should actively seek FDI that facilitates the establishment of R&D centres, promoting innovation and advanced technologies, ultimately moving beyond repetitive tasks to activities that generate higher added value. For this to succeed, Serbia's education system must align with the requirements of the digital era, ensuring that the nation has a well-educated and highly skilled workforce capable of innovation and advanced technology utilization. Collaborative efforts between the public and private sectors should foster an environment conducive to knowledge transfer and technological advancement, positioning Serbia as a regional hub for innovation and high-value-added manufacturing.

5.2 Educational Initiatives

Strengthening science, technology, engineering, and mathematics (STEM) education, fostering collaboration between academia and industry, and drawing inspiration from successful models in developed countries are pivotal steps toward ensuring that Serbia's workforce is well-prepared for the challenges and opportunities of the digital era.

One of the foundational steps to prepare the workforce for Industry 4.0 is to boost science, technology, engineering, and mathematics (STEM) education. By strengthening STEM programs at various educational levels, Serbia can cultivate a pool of talent equipped with essential skills. This entails updating the curricula to align with the latest industry trends and technological advancements. Beyond textbook knowledge, practical applications and critical thinking in STEM subjects should be emphasized. Encouraging students' interest in STEM from an early age through engaging and innovative teaching methods can help build a strong foundation. Additionally, extracurricular activities, such as coding clubs and science competitions, can stimulate curiosity and interest in these fields.

Serbia should help in the creation of partnerships between academic institutions and industry experts. A seamless collaboration between academic institutions and industry experts is vital for ensuring that education remains relevant and up-to-date. These partnerships can take

various forms, such as internships, apprenticeships, and joint research projects. By working closely with industry professionals, students gain practical exposure and insights into real-world challenges. This hands-on experience not only enhances their understanding but also makes them more attractive candidates for employers. Furthermore, such partnerships can lead to the co-creation of curricula that are aligned with the skills the industry demands. This fosters a direct link between education and the workforce, ensuring that graduates possess the practical skills and knowledge required for Industry 4.0 careers.

To advance into a more developed educational system tailored for Industry 4.0, Serbia can examine educational initiatives in developed countries. Countries like Finland, Germany, and Singapore are known for their highly effective educational systems. By studying their successful models and best practices, Serbia can gain valuable insights. This includes understanding their approaches to curriculum development, teacher training, and educational policies. Furthermore, exploring how these countries integrate technology and innovation into their educational systems can provide a blueprint for Serbia to follow. By learning from the experiences of these nations, Serbia can adapt and implement the most relevant strategies, saving time and resources in the process.

5.3 Continuous Workforce Development

The concept of continuous workforce development is pivotal in ensuring that employees are well-equipped with the evolving skills necessary for a dynamic technological environment. Upskilling the workforce is essential for Industry 4.0 success.

Training and upskilling program initiatives serve as the backbone of maintaining a future-ready workforce, equipping employees with the knowledge and skills needed to thrive in the evolving landscape of Industry 4.0. These programs should continually evolve to match the pace of technological advancements and the specific needs of the organization. In the context of Industry 4.0, the roles of employees are not set in stone. They transform as new technologies emerge, and business processes become more automated and data-driven. Consequently, employees must be able to swiftly acquire new proficiencies and adapt to their evolving roles.

Creating and adopting a culture of learning is a fundamental aspect of motivating employees to participate actively in their continuous development. In an era where adaptability and the rapid acquisition of new skills are paramount, cultivating a learning culture is not just beneficial but essential for organizations aiming to thrive in the Industry 4.0 landscape. A learning culture encourages employees to take the initiative in upskilling and staying updated on industry trends. Organizations should prioritize the cultivation of a learning culture, which hinges on dedicated leadership, transparent communication, accessible learning resources, curiosity celebration, knowledge sharing, feedback mechanisms, flexible learning paths, embracing failure as a learning opportunity, feedback loops, and ensuring accessibility and inclusivity.

While developing strategies for continuous workforce development, gathering insights from global best practices is paramount. By examining what has worked in other countries and industries, Serbia can gather valuable lessons that can be implemented to strengthen its workforce. Learning from the experiences of developed nations in terms of training, upskilling, and building a culture of learning can expedite Serbia's journey toward an Industry 4.0-ready workforce.

5.4 Government Initiatives

The Government of the Republic of Serbia has launched a series of initiatives for the development of the digital economy, ICT industry, and Industry 4.0 in general in Serbia. Some of these initiatives include:

- National Program for the Development of Information Society: this program aims to improve the use of information and communication technologies in society and the economy, as well as to stimulate the development of the digital economy (Government of the Republic of Serbia, 2021).
- Startup Serbia Program: this program aims to support the development of startups in the country. The program includes financial support, counselling, and mentoring programs for young entrepreneurs (Startup Serbia, 2022).
- Digital Serbia: this is an initiative aimed at positioning Serbia as a leader in the field of the digital economy in the region. The initiative focuses on infrastructure development, education, and R&D as well as on promoting entrepreneurship (Digital Serbia Initiative, 2022).
- Smart Serbia: this program aims to improve the use of information and communication technologies in the public sector, as well as to stimulate the development of smart cities and services in Serbia (Office for IT and eGovernment, 2021).
- Support Program for the Development of the ICT Industry: this program aims to stimulate the development of the ICT industry in Serbia through financial support for research and development, as well as for the creation of new jobs in the sector (Government of the Republic of Serbia, 2020).
- To harness the full potential of these government initiatives and accelerate Serbia's transition to Industry 4.0, it is essential to ensure that these programs are effectively integrated. Cross-collaboration among these initiatives can yield comprehensive outcomes. For instance, the National Program for the Development of Information Society can collaborate with the Support Program for the Development of the ICT Industry to create a holistic approach, ensuring that financial support is not only accessible but also aligned with the latest industry trends. The government should actively promote cross-sector partnerships with the Startup Serbia Program, allowing startups to collaborate with other sectors like smart cities and digital services in Smart Serbia, creating a more interconnected and innovative ecosystem. This synergy ensures

that the initiatives collectively drive the digital transformation of the economy while supporting innovative entrepreneurs in their endeavours.

To establish a thriving digital ecosystem, Serbia must prioritize the creation of collaborative platforms that facilitate knowledge sharing and idea exchange. Investing in innovation hubs becomes pivotal, providing fertile grounds for startups, tech companies, and academic institutions to converge, driving creativity and breakthrough solutions. Accessibility to funding is equally crucial, ensuring that financial resources are not a barrier to innovative ideas. By fostering an ecosystem where resources, talent, and knowledge flow seamlessly, Serbia can accelerate its journey toward Industry 4.0.

Serbia's roadmap to Industry 4.0 should focus on building a robust smart infrastructure, particularly in regions central to manufacturing. Reliable connectivity forms the core of Industry 4.0 technologies, and targeted investment in these areas ensures that digital transformation can proceed unhindered. This infrastructure must encompass high-speed networks, data centres, and cybersecurity measures to safeguard data integrity. Furthermore, the development of smart manufacturing zones and industrial parks equipped with advanced facilities is essential to empower businesses with the tools needed to adopt IoT technologies seamlessly.

In the pursuit of Industry 4.0, Serbia should actively foster collaboration that extends beyond manufacturing, particularly by promoting cross-sector collaboration. Encouraging partnerships between manufacturers and other sectors, such as healthcare, agriculture, and logistics, present an avenue for novel solutions and innovative business models. These cross-sector collaborations can spark innovative applications, with manufacturing expertise meeting the unique demands of diverse industries. By breaking down traditional silos, Serbia can harness the full potential of Industry 4.0 technologies to drive economic growth and technological advancement across various sectors.

5.5 National Industry 4.0 Strategy

Although Serbia is not a member of the European Union, it has still linked the transformation of its society and economy with it. In the year 2000, the EU set development goals for its members called the "Lisbon Strategy", which directly linked the building of a digital society with the existence and accessibility of ICT to all members of society, all organizations, in short - the entire society. The EU's focus was precisely on ICT, on improving infrastructure and connections. Serbia has joined these strategic goals. These are just some government strategies and papers related to digital and information technology in Serbia:

- The Industrial Policy Strategy of the Republic of Serbia from 2021-2030 - is an important government strategy that aims to develop the country's industrial sector and improve its competitiveness. The strategy outlines a set of policies and measures to support the growth and modernization of Serbian industries, including improving the business

environment, promoting innovation and research, and attracting foreign direct investment. The strategy also emphasizes the need to address social and environmental issues related to industrial development and to promote sustainable and inclusive economic growth (Government of the Republic of Serbia, 2021).

- Information Society Development Strategy of the Republic of Serbia for the Period 2021-2026 - This strategy aims to promote the use of information and communication technologies (ICT) in society and the economy, as well as to support the development of a digital society (Government of the Republic of Serbia, 2021).
- Smart Specialization Strategy for Innovation in Serbia (S3 Serbia) 2020-2027 - is a government strategy aimed at identifying and promoting areas of economic activity where Serbia has the potential to achieve a competitive advantage through innovation and to support the development of innovative solutions in key sectors, such as ICT, advanced manufacturing, and agro-food. The strategy is focused on developing the country's innovation ecosystem by promoting cooperation between universities, research institutions, and industry (Government of the Republic of Serbia, 2020).
- Cyber Security Strategy of the Republic of Serbia for the Period 2021-2025 - This strategy aims to strengthen the protection of information and communication systems and networks, as well as to increase the resilience of the country's critical infrastructure against cyber threats (Government of the Republic of Serbia, 2021).
- E-Government Development Strategy for the Period 2021-2025 - This strategy aims to improve the delivery of public services to citizens and businesses, through the use of ICT and the development of e-government services (Government of the Republic of Serbia, 2021).
- National Artificial Intelligence Strategy for the Republic of Serbia for the Period 2021-2025 - This strategy aims to support the development and use of artificial intelligence in the country, in order to improve the efficiency and competitiveness of key sectors, such as healthcare, agriculture, and industry (Government of the Republic of Serbia, 2021).
- National Cloud Strategy of the Republic of Serbia for the Period 2020-2025 - This strategy outlines the goals and objectives of Serbia's cloud computing efforts and sets out a roadmap for achieving those objectives. It aims to promote the adoption of cloud technology across government agencies and the private sector, to increase efficiency and reduce costs. The strategy also focuses on building a regulatory framework for cloud computing, developing the necessary infrastructure, and ensuring data security and privacy (Government of the Republic of Serbia, 2020).
- The overall goal for Serbia with all these above-mentioned strategies is to create a modern, digitalised, and innovative society, economy, and government that can compete globally. Serbia aims to develop a strong and resilient digital infrastructure, foster innovation and entrepreneurship, and increase the adoption of digital technologies across all sectors.

Serbia should focus its resources the most on developing a strong manufacturing sector and here new technologies could play a crucial role for Serbia to become a more competitive

player in the global market. By investing in the development of the manufacturing sector and leveraging new technologies such as AI, IoT, and 5G, Serbia can improve its competitiveness and attract more foreign investments. The Industrial Policy Strategy of the Republic of Serbia for 2021-2030 acknowledges the importance of the manufacturing sector and aims to strengthen it through various measures, including the development of industrial clusters, improvement of workforce skills, and the creation of more favourable business conditions.

By focusing on the manufacturing sector, Serbia can tap into its strong industrial heritage and achieve sustainable economic growth. With its strategic location and the availability of a highly skilled workforce, Serbia has the potential to become a regional manufacturing hub, attracting investors looking for low-cost production and a favourable business environment. By embracing new technologies, Serbia can also foster innovation and create new business opportunities in the manufacturing sector, further enhancing its competitiveness on the global market. Therefore, it is crucial that Serbia prioritizes the development of the manufacturing sector and invests in new technologies to achieve its goal of becoming a more competitive player in the global market.

6 CONCLUSION

The advancement of Industry 4.0 represents a remarkable and transformative era. It offers an unprecedented opportunity for innovation, growth, and enhanced competitiveness, not only within the manufacturing sector but across all industries. Industry 4.0 holds the potential to support the overall quality of life in areas where its principles are applied.

Nonetheless, besides the optimism surrounding this technological revolution, there are some uncertainties, particularly regarding the distribution of benefits. While there is a consensus regarding the advantages that the Industry 4.0 brings to the economy and society, there are conflicting opinions on how it might influence existing social disparities. Consequently, the recognition that addressing social differences is integral to achieving comprehensive economic development highlights the significance of Industry 4.0 as an opportunity to expedite progress and overcome the productivity stagnation witnessed globally over the past few decades.

The research tried to provide a general understanding of Industry 4.0, specifically within the context of Serbian companies. It focused into critical aspects, exploring the transformative power of Industry 4.0 and its impact on businesses. Additionally, the study involved an examination and benchmarking of Serbia's technological development against global standards, particularly those set by the European Union. At the micro-level, the adoption of Industry 4.0 technologies within organizations was analysed, with a focus on the factors influencing managerial decision-making. The research also considered the context of the global health crisis (COVID-19) and its effects on technological investments and long-term

strategies. Finally, an examination of the government's Industry 4.0 strategies was conducted, highlighting their role in stimulating technological restructuring within the country.

In addition to the previously mentioned points, in the context of Serbia, notable progresses have been taken in the adoption of Industry 4.0 technologies, highlighting the country's commitment to keep the pace with global industrial trends. Nevertheless, as the research highlights, there are considerable gaps and challenges that need attention. Some of these obstacles are investment strategies, educational initiatives, continuous workforce development and government policies. Addressing these issues is vital for Serbia to fully realize the potential of Industry 4.0. Therefore, to truly succeed in the Industry 4.0 landscape, Serbia must embrace a general and strategic approach which will enable the comprehensive transformation of manufacturing processes, workplace dynamics, and business models.

REFERENCE LIST

1. Andrejić, M. (2019). *Kako je propala proizvodnja u Srbiji Zaostajemo pet tehnoloških generacija, i to zbog tri velike greške*. https://www.blic.rs/biznis/vesti/kako-je-propala-proizvodnja-u-srbiji-zaostajemo-pet-tehnoloskih-generacija-i-to-zbog/hlfgw91
2. Arden, N. S., Fisher, A. C., Tyner, K., Yu, L. X., Lee, S. L., & Kopcha, M. (2021). *Industry 4.0 for pharmaceutical manufacturing: Preparing for the smart factories of the future.* International Journal of Pharmaceutics. https://www.sciencedirect.com/science/article/pii/S0378517321003598
3. Arsić, M. (2016). *Long run consequences of economic collapse of serbian economy during the nineties of the 20th century*. https://www.semanticscholar.org/paper/Dugoro%C4%8Dne-Posledice-Ekonomskog-Sloma-Privrede-Tokom-Arsic/9030f734d81291788fd231506333bf97dd7c7c7c
4. Bukvić, Lj. (2019, December 21). *Za 11 godina iz Srbije se odselilo 500.000 ljudi—Ekonomija.* https://www.danas.rs/ekonomija/za-11-godina-iz-srbije-se-odselilo-500-000-ljudi/
5. Catts, T. (2019). *How can blockchain power industrial manufacturing?* https://www.pwc.com/us/en/library/4ir-ready.html
6. Deloitte Touche Tohmatsu. (2019). *The Fourth Industrial Revolution is here: Are you ready?* https://www.voced.edu.au/content/ngv:78821
7. Digital Serbia Initiative. (2022). https://www.dsi.rs/en/
8. Elizalde, D. (2018). *7 IoT Business Models That Are Transforming Industries*. https://danielelizalde.com/monetize-your-iot-product/
9. Eurostat. (2023). Eurostat. https://ec.europa.eu/eurostat
10. Geissbauer, R., Schrauf, S., Schneider, J., & Hermans, M. (2020). *Connected and autonomous supply chain ecosystems 2025.* https://www.pwc.com/us/en/library/4ir-ready.html

11. Government of the Republic of Serbia. (2020). *Strategija industrijske politike Republike Srbije od 2021. do 2030. godine*. https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2020/35/1/reg
12. Government of the Republic of Serbia. (2021). *Strategija razvoja informacionog društva i informacione bezbednosti u Republici Srbiji za period od 2021. do 2026. godine.* http://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2021/86/1/reg
13. Gregory, L. (2019). *Timeline of Revolutions*. https://www.industrialiotseries.com/newsroom/timeline-of-revolutions/
14. Hajj, R., Peasley, S., Hunt, J., & Beskoff, D. (2020). *Cyber security for smart factories.* Deloitte Touche Tohmatsu Limited. https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/smart-factory-cybersecurity-manufacturing-industry.html
15. Insights Team. (2018). *How IoT Is Spawning Better Business Models.* Forbes. https://www.forbes.com/sites/insights-inteliot/2018/06/27/how-iot-is-spawning-better-business-models/
16. Javaid, M., Haleem, A., Vaishya, R., Bahl, S., Suman, R., & Vaish, A. (2020). *Industry 4.0 technologies and their applications in fighting COVID-19 pandemic*. https://doi.org/10.1016/j.dsx.2020.04.032
17. Jordanoski, Z., & Meyerhoff, M. (2021). *Report on the state of application of digital economy society index (DESI) in Western Balkan Economies*. Regional Cooperation Council. https://www.rcc.int/pubs/125/report-on-the-state-of-application-of-digital-economy-society-index-desi-in-western-balkan-economies
18. Khan, A. (2008). *The Industrial Revolution and the Demographic Transition.* https://ideas.repec.org/a/fip/fedpbr/y2008iq1p9-15.html
19. Khan, S. N., Loukil, F., Ghedira-Guegan, C., Benkhelifa, E., & Bani-Hani, A. (2021). *Blockchain smart contracts: Applications, challenges, and future trends. Peer-to-Peer Networking and Applications*. https://doi.org/10.1007/s12083-021-01127-0
20. Kovačević, M. (2021). *Monthly statistical bulletin*. Statistical Office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2021/Pdf/G20213003.pdf
21. Madžar, L. (2021). *Domaće investicije su temelj države.* https://novaekonomija.rs/vesti-iz-izdanja/domace-investicije-su-temelj-drzave
22. Ministry of Finance. (2021). *Program Ekonomskih Reformi Za Period od 2021. do 2023. godine*. https://www.mfin.gov.rs/sr/dokumenti2-1/program-ekonomskih-reformi-erp-1
23. Mohajan, H. K. (2020). *The Second Industrial Revolution has Brought Modern Social and Economic Developments.* Journal of Social Sciences and Humanities. https://www.researchgate.net/publication/338670501_The_Second_Industrial_Revolution_has_Brought_Modern_Social_and_Economic_Developments
24. Mutray, C. (2020). *Ramp up cybersecurity as you double down on 4IR and innovation.* https://www.pwc.com/us/en/library/4ir-ready.html

25. Nair, M. M., Tyagi, A. K., & Sreenath, N. (2021). *The Future with Industry 4.0 at the Core of Society 5.0: Open Issues, Future Opportunities and Challenges.* IEEE. https://doi.org/10.1109/ICCCI50826.2021.9402498
26. National Bank of Serbia. (2023). *Macroeconomic trends in Serbia* https://www.nbs.rs/export/sites/NBS_site/documents/finansijska-stabilnost/prezentacije/prezentacija_invest.pdf
27. Nikolić, M. (2017). *O dva veka razvoja Srbije*. Statistical Office of the Republic of Serbia. http://publikacije.stat.gov.rs/G2017/Pdf/G20176011.pdf
28. Nova ekonomija. (2019). *Zašto su investicije u Srbiji niske?* https://novaekonomija.rs/vesti-iz-zemlje/zašto-su-investicije-u-srbiji-niske
29. Office for IT and eGovernment. (2021). *„Pametna Srbija"—Nova državna platforma za masovnu obradu podataka predstavljena u Državnom data centru u Kragujevcu.* http://www.ite.gov.rs/vest/sr/5797/pametna-srbija-nova-drzavna-platforma-za-masovnu-obradu-podataka-predstavljena-u-drzavnom-data-centru-u-kragujevcu.php
30. Schroeder, W. (2016). *Germany's Industry 4.0 strategy.* https://www.scribd.com/document/465016022/FES-London-Schroeder-Germanys-Industrie-40-Strategy
31. Schwab, K. (2016). *The Fourth Industrial Revolution: What it means and how to respond.* World Economic Forum. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
32. Sisinni, E., Saifullah, A., Han, S., Jennehag, U., & Gidlund, M. (2018). *Industrial Internet of Things: Challenges, Opportunities, and Directions.* IEEE. https://doi.org/10.1109/TII.2018.2852491
33. Stamenković, I., & Vučković, N. (2019). *Vodič kroz direktne strane investicije u Srbiji.* Bankar.rs. http://bankar.rs/2019/09/27/vodic-kroz-direktne-strane-investicije-u-srbiji/
34. Startup Serbia. (2022). *Startap Portal.* https://startap.gov.rs/
35. Statistical Office of the Republic of Serbia. (2023). *Home* https://www.stat.gov.rs/en-us/
36. Storm, S., & Gumbel, P. (2021). *The future of work after COVID-19*. https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19
37. Sulavik, C., & Waller, T. (2020). The fourth industrial revolution: A recovery plan for today's economic storm. https://www.pwc.com/us/en/library/4ir-ready.html
38. Sulavik, C., Waller, T., & Callaway, J. (2017). Monetizing the Industrial Internet of Things. https://www.pwc.com/us/en/library/4ir-ready.html
39. Trading Economics. (2023). *Trading Economics.* https://tradingeconomics.com/
40. Vasiljević, A. (2021). *Rekordno negativan prirodni priraštaj u Srbiji.* http://www.politika.rs/scc/clanak/473686/Rekordno-negativan-prirodni-prirastaj-u-Srbiji
41. Villagrán, N. V., Estevez, E., Pesado, P., & Marquez, J. D. J. (2019). *Standardization: A Key Factor of Industry 4.0*. https://doi.org/10.1109/ICEDEG.2019.8734339

42. Viorel, P. (2019). *Top 3 Industrial IoT Business Models. IIoT-World.Com.* https://iiot-world.com/industrial-iot/connected-industry/top-3-industrial-iot-business-models/
43. Wang, J., Xu, C., & Zhang, J. (2022). *Big data analytics for intelligent manufacturing systems.* https://www.sciencedirect.com/science/article/abs/pii/S0278612521000601
44. Woschank, M., Rauch, E., & Zsifkovits, H. (2020). *A Review of Further Directions for Artificial Intelligence, Machine Learning, and Deep Learning in Smart Logistics*. https://doi.org/10.3390/su12093760
45. Zdravković, M. (2020). *Industrijska proizvodnja u EU i u Srbiji, 1990-2020.* https://www.makroekonomija.org/0-miroslav-zdravkovic/industrijska-proizvodnja-u-eu-i-u-srbiji-1990-2020/
46. Zheng, T., Ardolino, M., Bacchetti, A., & Perona, M. (2021). *The applications of Industry 4.0 technologies in manufacturing context.* https://doi.org/10.1080/00207543.2020.1824085

APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Četrta industrijska revolucija, znana kot Industrija 4.0 prinaša napredne tehnologije, ki spreminjajo način poslovanja podjetij v digitalni dobi. Te tehnologije prinašajo številne koristi, kot so izboljševanje produktivnosti, večja transparentnost procesov, ustvarjanje novih poslovnih modelov, izboljšanje kakovosti izdelkov in pogojev dela.

Ta revolucija povečuje učinkovitost operacij, zmanjšuje stroške in ohranja vire. Tehnologije Industrije 4.0 podjetjem omogočajo vpogled v njihove operacije v realnem času, kar omogoča hitro prilagajanje spremembam na trgu. Pametni izdelki in stroji zbirajo podatke za razvoj novih izdelkov, optimizacijo proizvodnih procesov in zagotavljanje inovativnih storitev.

Vendar pa je vpliv Industrije 4.0 na podjetja velik zaradi izzivov, kot so varnost informacijske tehnologije, zaščita podatkov, organizacija dela, izobraževanje zaposlenih in potreba po standardiziranih praksah v digitalni ekonomiji.

Ta študija si poskuša raziskati svet Industrije 4.0, razkriti njen potencial in razumeti, kako vpliva na podjetja. Poskusil sem pojasnit kaj pomeni Industrija 4.0, njene različne vidike in kako se podjetja lahko z njo razvijajo ter rešujejo izzive. Predstavljen je tudi pregled ključnih tehnologij, kot so Internet stvari, umetna inteligenca in strojno učenje, skupaj z razlagami, kako se lahko te tehnologije izkoristijo. Poleg tega sem raziskal to kompleksno temo, pri čemer sem upošteval tako priložnosti kot izzive.

Cilj raziskave je ponuditi praktična priporočila, ki jih lahko podjetja, ne glede na njihovo velikost ali strokovnost, sprejmejo. Motivacija za to raziskavo je razumevanje kaj spodbuja podjetja k vlaganju v napredne tehnologije, raziskovanje odnosov in dojemanja vodstvenega kadra glede implementacije tehnologij Industrije 4.0 ter prepoznavanje značilnosti implementacije novih tehnologij na organizacijski ravni.

Zaključno lahko rečem, da je Industrija 4.0 tako obljuba kot izziv in s to raziskavo si želim razširiti trenutno znanje in razumevanja tega kompleksnega področja.

Appendix 2: Questionnaire

Question 1: What advanced technologies are currently implemented in your organization? (Please select multiple, if applicable)

- Internet of Things (IoT)
- Artificial Intelligence (AI)
- Machine Learning
- Big Data Analytics
- Robotics and Automation
- Digital twin
- Cloud Computing
- Advanced Manufacturing Technology
- Additive Manufacturing (3D Printing)
- Advanced Materials
- Cybersecurity Solutions
- Augmented Reality (AR) and Virtual Reality (VR)
- Blockchain Technology
- Advanced Data Visualization Tools
- Nanotechnology
- Others (please specify)

Question 2: Does your enterprise use the following business software?

- Enterprise Resource Planning (ERP) software (Software used to manage resources by sharing information among different functional areas, e.g. accounting, planning, production, marketing,)
- Customer Relationship Management (CRM) software (Software for managing information about customers (e.g. relations or transactions)
- Business Intelligence (BI) software (software that integrates data from multiple sources, such as databases, spreadsheets, and other data repositories, and applies various analytical techniques to extract meaningful information)

Question 3: To what extent does your company's existing strategy address digitalisation and Industry 4.0?

- Digitalisation and Industry 4.0 are not mentioned in our strategies.
- Digitalisation and Industry 4.0 are mentioned in our strategy, but we do not have a separate digitalisation strategy.
- We have a separate digitalisation strategy in progress.
- We are implementing pilot projects related to digitalisation and Industry 4.0.
- Our strategy fully encompasses digitalisation and Industry 4.0.

Question 4: On a scale 1-5 please evaluate the importance of following factors for implementing Industry 4.0 technologies in your company?

- Enhancing operational efficiency
- Increased quality and reliability of products and services
- Increasing productivity
- Enabling data-driven decision-making
- Enabling predictive maintenance and reducing downtime
- Greater flexibility and agility in operations
- Gaining a competitive advantage
- Better horizontal/vertical integration
- Enhancing safety and risk management
- Meeting customer demands and expectations
- Addressing workforce challenges (e.g., labour shortages, skill gaps)
- Other (please specify)

Question 5: On a scale 1-5 please rate your company's management attitudes towards Industry 4.0 implementation?

- Management had dedicated a digital budget
- Management actively promotes and supports Industry 4.0 initiatives
- Clear communication of Industry 4.0 goals and objectives throughout the organization
- Allocation of dedicated resources and budget for Industry 4.0 implementation
- Emphasis on continuous learning and upskilling of employees for Industry 4.0
- Proactive approach to identifying and adopting emerging technologies
- Regular monitoring and evaluation of Industry 4.0 progress and outcomes
- Alignment of Industry 4.0 initiatives with the overall business strategy
- Willingness to experiment and embrace innovation in the organization
- IT and other departments strongly cooperate in planning
- IT and other departments strongly cooperate in implementation
- Encouragement of cross-functional collaboration and knowledge sharing

Question 6: To what extent has the adoption of Industry 4.0 technologies influenced your company's decision-making processes and strategic planning? On a scale 1-5 (1 - Very little, 5 - Significantly), please rate these processes.

- Resource allocation and investment decisions
- Supply chain optimization and logistics planning
- Market analysis
- Customer segmentation
- Competitive intelligence and benchmarking
- Risk assessment and mitigation strategies

- Sustainability and environmental impact considerations
- Branding and marketing strategies
- Expansion and market entry strategies
- Product portfolio management and diversification strategies
- Other (please specify)

Question 7: On a scale 1-5 (where 1 is "Very Easy" and 5 is "Very Difficult") please rate the main obstacles or challenges your company has encountered during the implementation of Industry 4.0 technologies?

- Lack of skilled workforce
- High implementation costs
- Resistance to change among employees
- Data privacy concerns
- Lack of technical support and expertise
- Limited access to advanced technology infrastructure
- Difficulty in identifying suitable technology solutions for specific business needs
- Regulatory or compliance issues
- Uncertain return on investment (ROI)
- Supplier or partner readiness and compatibility
- Lack of awareness or understanding of Industry 4.0 concepts
- Other (please specify)

Question 8: On a scale 1-5 please rate how important for you are following collaborators in relation to actual implementation of Industry 4.0 initiatives?

- Chamber of commerce
- Government agencies
- External partners
- Funding programs
- Industry associations
- Universities
- Research institutions
- Startups and innovation hubs
- Consulting firms
- International organizations or agencies
- Other (please specify)

Question 9: Did you use any state subsidies or EU subsidies to help finance the implementation of Industry 4.0 technologies?

- Yes

- No
- If yes, which (please specify)

Question 10: How would you rate your company's overall performance compared to other companies in your industry? (1 - Significantly worse, 5 - Significantly better)

- Revenue Growth
- Profit Margin
- Return on Investment
- Return on Asset
- Productivity
- Market Share
- Cost Reduction
- Time-to-Market
- Inventory Turnover
- Supply Chain Efficiency
- Customer Acquisition and Retention
- Product/service quality
- Product/service performance
- Employee Engagement and Satisfaction
- Innovation and New Product Development
- Overall Performance Improvements

Question 11: If you have implemented at least one Industry 4.0 technology, on a scale of 1-5, please select the benefits or improvements you have observed as a result of implementing these technologies (1- No noticeable benefits or improvements observed, 5 - Substantial benefits or improvements observed) (Please select multiple, if applicable)

- Increased operational efficiency
- Improved product quality
- Enhanced decision-making capabilities
- Cost reduction
- Development of new products and services
- Product and service customization
- Improved customer satisfaction
- Improved competitiveness
- Process improvement
- Improved innovation
- Enhanced value added
- Enhanced supply chain management
- Greater operational flexibility

– Increased data security
– Better overall performance
– Less errors
– Other (please specify)
– No benefits or improvements

Question 12: If you did not implement any of Industry 4.0 technologies, on a scale of 1-5, what do you think, how would implementing these technologies potentially benefit your company? (1- No visible benefits or improvements, 5 - Substantial benefits or improvements) (Please select multiple, if applicable)

– Increased operational efficiency
– Improved product quality
– Enhanced decision-making capabilities
– Cost reduction
– Development of new products and services
– Product and service customization
– Improved customer satisfaction
– Improved competitiveness
– Process improvement
– Improved innovation
– Enhanced value added
– Enhanced supply chain management
– Greater operational flexibility
– Increased data security
– Better overall performance
– Less errors
– Other (please specify)
– No benefits or improvements

Question 13: Has the COVID-19 pandemic influenced the motives for implementing Industry 4.0 technologies in your company? If yes, how? Please provide specific examples or details.

Question 14: What is the size of your company in terms of employees?

– 1-9;
– 10-49
– 50-249
– 250+

Question 15: What is your company's annual revenue for the previous fiscal year?

- Less than 1 million €
- 1 million € - 10 million €
- 10 million € - 50 million €
- 50 million € - 100 million €
- Over 100 million €

Question 16: What is the approximate value added per employee for your company?

- Less than €50,000
- €50,000 - €100,000
- €100,000 - €200,000
- €200,000 - €500,000
- Over €500,000

Question 17: Which sector does your company belong to?

- C: Processing industry
- D: Electricity, gas, steam, and air conditioning supply
- E: Water supply; waste water management, waste removal, and similar activities
- F: Construction
- G: Wholesale and retail trade; repair of motor vehicles and motorcycles
- H: Transportation and storage
- I: Accommodation and food service activities
- J: Information and communication technologies
- K: Financial and insurance activities
- L: Real estate activities
- M: Professional, scientific, and technical activities
- N: Administrative and support service activities
- P: Education
- S: Other service activities

Question 18: What is your role or position in the company?

Question 19: How many years have you been employed with current employer?