BEYOND BITS AND ALGORITHMS:

REDEFINING BUSINESSES AND FUTURE OF WORK

EDITORS:
POLONA DOMADENIK MUREN, MATJAŽ KOMAN, TJAŠA REDEK

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Contents

PREFACE

"Beyond bits and algorithms: Redefining businesses and future of work" is the culmination of a year's worth of dedicated effort by a select team of researchers, including *Pavle Boškoski, Andreja Cirman, Barbara Čater, Tomaž Čater, Polona Domadenik Muren, Daša Farčnik, Uroš Godnov, Aleš Gorišek, Tanja Istenič, Jakob Jelenčič, Matjaž Koman, Hana Končan, Mitja Kovač, Mateja Kos Koklič, Denis Marinšek, Eva Marčič, M. Besher Massri, Mauro Pregarc, Rok Požun, Tjaša Redek, Nada Zupan and Vesna Žabkar*, and the students of the 30th generation of the International Master Programme in Business and Organisation (IMB) at the School of Economics and Business, University of Ljubljana. Their collective dedication and insights were invaluable to the research.

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Introduction

Artificial Intelligence (AI) is one of the key technologies of the future that, together with other technologies of the 4th Industrial Revolution, will revolutionise the economy, accelerate its growth and co-create the so-called 'Society 5.0'. AI holds a prominent position in today's technological landscape, primarily driven by breakthroughs like ChatGPT. However, it is crucial to recognise that ChatGPT represents just a fraction of AI's overall progress. The path of AI development extends far beyond this single facet, encompassing numerous unexplored territories. As a comprehensive concept, AI remains hard to define due to its vast scope and constantly evolving nature. In theory, it refers to 'machine or artificial intelligence', i.e. a computer or computer robot performing tasks that would otherwise be attributed to 'intelligent beings' (OECD, 2023).

AI technologies are divided in several different ways, with the basic division being 'narrow-weak' and 'broad-strong'. 'Narrow or weak AI' is used as a description for a number of highly advanced solutions and technologies, from Apple's Siri and Amazon's Alexa to autonomous vehicles. In the realm of knowledge work automation, Artificial Narrow Intelligence (ANI) systems have found extensive application in chatbots, catering to various sectors such as banks, airline hotlines, and online consultations (Jarrahi, 2018). 'Strong AI', on the other hand, consists of Artificial General Intelligence (AGI), which represents the second stage of AI development, where humans interact with AI systems so that technology augments their capabilities (AI serves as an omnipotent helper). At the third stage, usually referred to as a stage of technological singularity, Artificial Super-Intelligence (ASI) may be able to create better AI systems than humans. Silicon-based beings could learn from experience, adapt to novel situations, comprehend abstract concepts, and utilise acquired knowledge to manipulate the surrounding environment (Jiang et al., 2022). Today, this is still a theoretical concept. Before proceeding with further advancements in AI development, it is crucial to understand the factors underlying AI reasoning and develop a means of correct interpretation. A rapidly evolving research field known as Explainable AI (XAI) has emerged to comprehend how AI functions, including the factors and logic that drive decision outputs. Regarding policy and law, AI responsibility for errors and failures still lacks maturity, hindering the ability to reach justifiable decisions (McDermid et al., 2021).

Although it might seem that AI is a relatively novel concept, many AI forms have already been used for a long time. Artificial intelligence is currently used in business for many different purposes. According to the existing statistical definition (Statistical Office of the Republic of Slovenia (SORS), 2021), AI incorporates (1) technologies used for *"(a) analysing written languages (text mining), (b) object or person recognition based on images (c) converting spoken language into machine-readable formats (a chatbot or virtual business assistant), (d) generating written or spoken language; (e) machine-learning-based data analysis; (f) robotic process automation and (g) physical movement of machines with autonomous decision-making based on environmental observation."* (2) However, as SORS (2021) points out, artificial intelligence is also embedded in the device itself and performs certain functions together with the device (e.g., an autonomous robot to automate activities in a warehouse). Artificial intelligence is used in many fields: (a) business, (b) households, (c) education, (d) healthcare, (e) logistics and transport, (f) commerce, and many others, with the simultaneous development of AI and other technologies enabling increasingly advanced applications (Simon, 2019).

As broad or 'powerful' artificial intelligence is developing fast, it is difficult to predict where it will be used, although the literature warns that many breakthroughs can be expected. First, AI is expected to reach a level where machines can exhibit patterns that human intelligence is capable of, which the literature defines as 'powerful AI'. In contrast, 'super AI', i.e. super powerful AI, is already being predicted, with machines and the accompanying software being able to surpass human cognitive abilities, which realistically is not expected to happen before 2100 (JavaPoint, 2022).

New technologies are expected to affect the economy and society more than any other technological revolution so far. They are hoped to increase productivity growth, improve efficiency, speed, and quality, and have other positive effects on companies in terms of their performance. However, on the other hand, cybersecurity, intellectual property and related challenges are putting a lot of strain on legislators and companies. New AI technologies are introducing changes and uncertainty into the world of work. The influence of AI on workers is expected to have both positive and negative effects.

On the positive side, AI will automate repetitive tasks, allowing workers to focus more on higher-level tasks. An increase in efficiency and productivity at the individual level will increase wages for individuals possessing skills to leverage these new AI technologies (OECD, 2023). On the negative side, the displacement of workers whose skills will be replaced could potentially lead to reduced wages and diminished employment opportunities for certain segments of the workforce. According to the estimates of the Organization for Economic Cooperation and Development (OECD), a quarter of existing jobs will be at risk in the coming years as they will be partially or fully replaced by AI technologies. Some other estimates mention that about half of the global workforce will need upskilling and reskilling by 2030 (World Economic Forum, 2021). In Slovenia, automation is expected to endanger as much as 31 percent of jobs, considering that this estimate was made before the broader accessibility of AI technologies based on the adoption of large language models (OECD, 2023). This assessment places Slovenia in a group of OECD countries where immediate action is necessary. But labour market impacts are only one aspect of the impact on humans. Technological change has already significantly changed the faces of communication, access to knowledge and information, and human interaction. It allows inventions that will further improve quality of life (e.g., new medicine) but also expose us to different risks, including privacy issues, the ability to recognise reality from AI images or news and others.

First, the definition of AI technologies is presented to comprehensively understand AI and its impacts. Then, the literature is summarised regarding the impact of AI technology adoption on business models in general and on strategy development, process efficiency and other aspects of business in detail. One of the most important characteristics of the AI revolution is its absorptive capacity. It is based mainly on the competencies of the workforce. It is crucial to understand the impact of AI technologies on particular tasks to design a proper model of reskilling and upskilling. Due to various challenges that have emerged, including issues of trustworthiness, privacy preservation, cybersecurity, social equality, policy and law, education, employment, and more (Jiang et al., 2022), regulation and cybersecurity are also discussed. In concluding remarks, the outline of the book is presented.

1 Defining artificial intelligence and AI technologies

AI research has been ongoing for over 65 years and has achieved remarkable advancements in theoretical understanding and real-world applications (Kaynak, 2021). It has become pervasive across various domains and is considered a vital skill for the future. The AI market is expected to reach a value of $190 billion by 2025, with a compound annual growth rate exceeding 36 percent between 2018 and 2025 (Jiang et al., 2022).

Since its emergence in the 1950s, AI has experienced cycles of hype and disillusionment (often referred to as AI winters), which involved significant dis-investment in the field. The resurgence of AI in the past decade could be attributed to several factors: (1) the development of critical machine learning theories and techniques such as decision trees, support vector machines, AdaBoost and random forest; (2) the availability of colossal datasets for training the models; (3) a significant increase in computer power; and (4) renewed public trust in AI after outperforming top human players in contests and competitions (Jiang et al., 2022).

Given the rapid pace of AI technology development and its ever-evolving nature, providing a precise and definitive definition of AI becomes exceedingly challenging. The latest AI technology patterns differ significantly from previous ones due to the recent surge in machine learning. Moreover, different institutions define AI differently. OECD defines an AI system as *"a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. It uses machine and/or human-based inputs to perceive real and/or virtual environments; abstract such perceptions into models (in an automated manner, e.g., with machine learning or manually); and use model inference to formulate options for information or action. AI systems are designed to operate with varying levels of autonomy"* (OECD, 2022). Eurostat's definition is a bit different: *"Artificial intelligence refers to systems that use technologies such as text mining, computer vision, speech recognition, natural language generation, machine learning, deep learning to gather and/or use data to predict, recommend or decide, with varying levels of autonomy, the best action to achieve specific goals. Artificial intelligence systems can be purely software-based, e.g., (1) chatbots and business virtual assistants based on natural language processing, (2) face recognition systems based on computer vision or speech recognition systems, (3) machine translation software, (4) data analysis based on machine learning, etc. or (5) embedded in devices (like autonomous robots for warehouse* *automation or production assembly works, autonomous drones for production surveillance or parcel handling, etc.)"* (Eurostat, 2021).

The definition of AI is critical since it affects its measurement. The broad range of AI functions includes (Dejoux and Léon, 2018; Collins et al., 2021):

- Expert Systems. Designed to simulate the problem-solving behaviour of a human.
- Machine learning. Automatically refines its methods and improves its results as it gets more data.
- Robotics. Concerned with the generation of computer-controlled motions of physical objects in various settings.
- Natural Language Processing. Designed to understand and analyse language as used by humans.
- Machine vision. The analysis of images using algorithmic inspection.
- Speech recognition. The translation of spoken words into text.

2 The determinants of corporate investment in artificial intelligence and new technologies

Investment in new technologies, including AI, is part of broader investment processes in the firms, often part of a more general modernisation of the processes, potentially being part of a wider investment plan and business model change at the firm level. Therefore, investments in new technologies depend on similar factors as other investment types. These can be classified in several different ways (Table 1). First, they depend on the general economic environment as well as global markets, industry-specific factors and firm-specific factors. All factors can contribute either positively or negatively to the general investment activity, which also includes investments in new technologies. At the firm level, investments (including technological) depend further on expected (positive) impacts, other proactive and reactive factors, as well as obstacles.

The macroeconomic environment, particularly GDP growth, is crucial for investments. Growing economies and growth in the export market stimulate investment more due to rising demand, while crises cause a decline or even a structural break in investments (Damijan et al., 2022; European Central Bank, 2017). Lower interest rates stimulate investments due to the lowering of investment costs and allowing easier access to capital (Bole et al., 2018). High-quality regulatory framework, stable business environment, and political stability attract investments, while higher taxation generally discourages investment (Alves, 2019; Leszczyłowska & Meier, 2021; Rodríguez-Pose & Ganau, 2022; Wang et al., 2020). Labour market legislation also impacts investment due to its impact on both labour market flexibility and costs (Cingano et al., 2009; Liotti, 2020; Rodríguez-Pose & Ganau, 2022). Investment is also affected by industry dynamics, speed of technological change by industry, global value chain (GVC) participation by sector and other factors, including environmental legislation (van Leeuwen & Mohnen, 2017; Yuan & Xiang, 2018; Zhou et al., 2019).

Table 1. Investment determinants at macro, industry and firm level

	Factors	Relevant references
Macroeconomic / business environment	GDP growth, interest rate, domestic and foreign demand, regulatory framework, business environment, green legislation, social legislation, taxation, labour legislation, policy support, financial markets, green finance, banking sector and access to capital, development of infrastructure, inclusion in global value chains.	(Alves, 2019; Bjelić et al., 2021; Djankov et al., 2008; European Commission, 2020, 2021; Ilmakunnas & Piekkola, 2014; Inessa et al., 2019; McGrattan & Prescott, 2010)
Industry level	Industry dynamics in comparison to the national level, specifics determining replacement dynamics, robotisation and digitalisation, technology obsolescence speed, environmental requirements, location of production, supplier and buyer characteristics, growth and requirements, competitiveness of an industry.	(Awad & Yussof, 2018; Hosono et al., 2020; Inklaar et al., 2019; Müller et al., 2018; Resler et al., 2018; Vrh, 2017)
Firm level	Impacts on firm efficiency / operational / short-term (e.g., lower cost, number of errors, business cycle duration and productivity). Impacts on firm effectiveness / strategic / long-term (e.g., value added, profitability and growth). **Internal/proactive factors:** competitive advantage, revenue and turnover growth, market share increase, productivity, speed, flexibility, process standardisation, economies of scale, customisation, satisfaction and motivation of employees, better decision-making, etc. **External/reactive factors:** regulatory factors, national strategies, competition, buyers and suppliers, requirements within the value chains, horizontal and vertical integration, etc. **Obstacles:** Economic and financial barriers, technical barriers, organisational and cultural barriers, legislation and government-related barriers.	(Bontempi & Mairesse, 2015; European Central Bank, 2017; European Investment Bank, 2021; Nonnis et al., 2023; Oliveira Neto et al., 2017; Piekkola, 2018; Piekkola et al., 2021; Piekkola & Rahko, 2020; Roth, 2022)

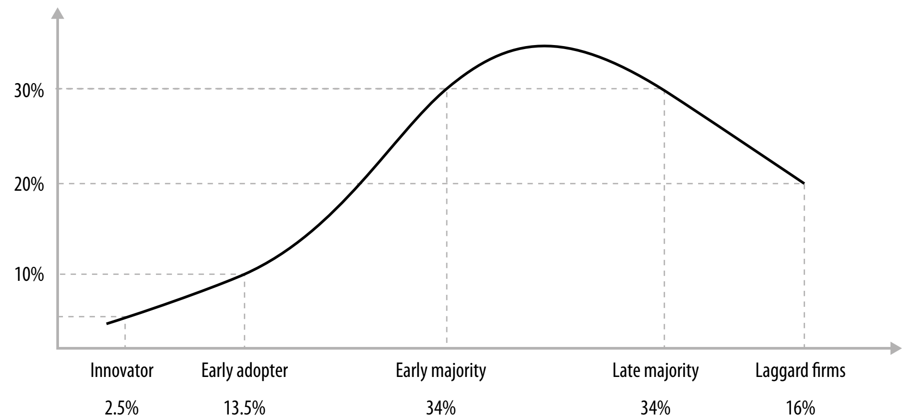
Source: Own work and Čater et al. (2019).

Firm-specific factors can be classified into several categories (Table 1, Čater et al., 2019). The determinants can first be classified as proactive or reactive. The proactive are, in particular, those decisions that firms make based on their strategic orientation and to actively pursue their goals, i.e., *"to bring about change in their current organisation"* (Brege & Kindström, 2020). Reactive factors are more often those external pressures that push companies towards change (Maravić, Čater & Redek, 2021), coming from regulation, policies, competition, buyers and suppliers, requirements within the value chains, requirements for change due to material and technology change, horizontal and vertical integration, etc. Companies invest in new technologies primarily due to the positive expected impacts, which can be classified into short-run efficiency and long-run strategic gains. Other factors, such as firm size, age, etc., also matter. There are also significant barriers in the process of new technology implementation, which can be classified into economic and financial, technical, organisational, cultural, and legislative/governmental (Čater et al., 2019).

Interestingly, in Slovenia in 2019, the most important obstacles were human resources, from the lack of knowledge, lack of skills, lack of time, and resistance to change between blue- and white-collar workers, which is often related to lack of knowledge as well (Čater et al., 2019, 2021). In 2022, due to the changed environment, financial obstacles became more important due to economic and political uncertainty; however, human resource obstacles were still in second place (Redek et al., 2023).

With regard to technology adoption, which includes artificial intelligence, additional factors must be considered as well. Companies differ in the speed of adoption of new technologies. Redek et al. (2023) divide these companies into several categories, following the core models in the field of technology adoption (Rogers, 2003; Venkatesh & Davis, 2000): technology enthusiasts (innovators), visionaries (early adopters of new technologies), pragmatic adopters (early majority), conservative adopters (late majority) or sceptics (laggards) (also Figure 1). The process of technology adoption often involves or is part of a broader organisational change. Therefore, it can partially be explained within the ADKAR organisational change model, which helps managers identify potential obstacles and create strategies to ensure that employees successfully adopt the changes. The following elements are essential (Hiatt, 2006): awareness, desire, knowledge, ability and reinforcement of processes in the company. These aspects can also be applied to technological change or AI adoption. Companies first need to create awareness about AI's benefits, stimulating the readiness or desire for adoption among employees. They must also provide the required training, allowing employees (and the company) to use AI effectively and promote successful adoption through suitable effort recognition and rewards (Kaminski, 2022). This approach helps employees accept general changes and new technologies, including AI.

Figure 1. Adoption of new technologies by company type – company distribution



Source: Harmon (2016).

The existing models in the literature may not be best suited for the adoption of new technologies of the 4th Industrial Revolution, including AI, primarily due to the speed and nature of change. But the basic principles would still hold, perhaps paying more attention to the accelerated adoption and the changed distribution of adopters, with possibly more than 2.5 percent innovators and more than 13.5 percent early adopters. The data shows that in Slovenia, around 11 percent of companies with at least ten employees already use AI, and the pace of technology adoption is fast (SORS, 2023). Also, product and technology change cycles differ and are possibly shorter despite significant differences across industries (Prašnikar, 2012). New technologies are also emerging and improving fast, which will continuously demand change in companies to stay competitive.

3 The effect of AI on the labour market

Over the past decade, the implementation of new digital technologies like robotics and automation has been relatively gradual, mainly impacting specific employee segments or tasks. However, artificial intelligence technologies are poised to have a much broader reach in the future. Not only will AI extend automation to tasks beyond routine non-cognitive activities, but as a general-purpose technology, it will also permeate all aspects of people's work and daily lives (Minevich, 2023). The swift development of AI applications for work processes, requiring minimal infrastructure investments compared to historical technological introductions like steam engines, electricity, the internet, and computers, is expected to also promote the adoption of AI at an exceptional pace (IBM, 2022; The Economist, 2023).

Moreover, as digitisation advances rapidly, the issue of knowledge and skills obsolescence in the workforce becomes more pronounced (Charles et al., 2022). The successful integration of new technologies within organisations will heavily depend on the absorptive capacity of individuals, which is linked to their digital competencies. The risk of being left behind in global value chains due to an inability to embrace these new technologies is becoming increasingly tangible.

At the macroeconomic level, digital technologies have not just automated a range of tasks previously performed by workers and impacted the wage structure but also have led to a polarisation of employment and wages – meaning that the negative effects have concentrated on employment and wages of middle-skill workers (Acemoglu & Restrepo, 2022). One significant literature stream links this phenomenon to 'Polanyi's paradox', embedded in the quote: *"We can know more than we can tell"* (Autor, 2014, 2015). Many manual and abstract tasks require substantial tacit knowledge, making them challenging to automate. On the other hand, routine tasks, more commonly undertaken by middle-skill workers, are more amenable to automation. As a result, new digital technologies, automation, and robotisation have displaced labour from these routine tasks. Acemoglu and Restrepo (2022) offered alternative explanations by focusing on tasks rather than on workers and their occupations. Middle-skill tasks are the most profitable to be substituted by machines. Low-skill tasks can be performed at lower labour expenses, reducing the cost advantage of machines relative to humans. Substituting low-skill tasks by machines would decrease profit. Polarisation is, therefore, the consequence of interior automation.

From a theoretical perspective, the effect of AI on the quantity of labour demanded is ambiguous (Charles et al., 2022). AI will displace human labour (displacement effect). Still, it can also raise labour demand in jobs not exposed to AI because of its greater productivity (productivity effect) and the creation of entirely new jobs (reinstatement effect). Which of these effects dominates, and whether aggregate labour demand increases or decreases, is unclear a priori.

However, not all workers are exposed to AI to the same degree, and the employment of certain groups may be more affected than others. Workers who perform a high share of non-routine cognitive tasks, such as white-collar professionals, have been the most exposed to advances in AI. The most basic building block for understanding the impact of AI on labour demand is tasks. The production of a final good or service requires the completion of a set of tasks, and groupings of tasks define production in a firm, a job, or an occupation. Drawing upon the framework proposed by Acemoglu and Restrepo (2019), where the direction of technological change, whether it leads to automation or introduces new tasks, is considered endogenous, labour market institutions could play an important role in influencing the direction of technical change.

4 Regulators and regulations: fighting technology with technology

"Laws and institutions must go hand in hand with the progress of the human mind. As that becomes more developed, more enlightened, as new discoveries are made, new truths disclosed, and manners and opinions change with the change of circumstances, institutions must advance also, and keep pace with the times" (Thomas Jefferson, 1816, published in Wadhwa, 2014).

Like previous technological advancements, the current AI debate extends beyond technical matters and sparks in-depth discussions on ethical, economic, political, sociological, and military aspects (Hennemann, 2019). Technology's impact goes beyond firm-level business efficiency and value-added improvements; it also influences market structure, economic dynamics, decision-making processes, business interactions, and even how companies may potentially violate competition laws. The rapid pace of technological development outstrips the human ability to follow and develop proper regulations to make markets work well for consumers, businesses and the economy. Using algorithms, an integral part of market and business operations, has greatly enhanced efficiency, enabled more sophisticated, sustainable and innovative products and services and decreased the hazard and monotonous work. However, there are instances where businesses exploit these algorithms to their advantage, capitalising on market problems and consumer vulnerabilities, undermining efforts to create a fair and competitive economy, a key goal of the program for Shaping Europe's Digital Future (European Commission, 2023a, 2023b). The misuse of algorithms poses potential harm to consumers and competition, particularly in areas of pricing, discrimination, and abuse of dominant positions. Concerns arise from the impact of automated pricing on collusion, the identification and assessment of personalisation effects, and the manipulative choice architecture, among others (OECD, 2021).

Digital markets are dynamic and, in many ways, different from traditional markets due to the influence of online platforms, data and algorithms. European Competition law is a crucial regulatory tool to maintain competition, foster innovation, and safeguard consumer interests; however, it requires adjustments to cater to the digital landscape. Establishing a foundation for fair and competitive digital markets involves harmonising regulations and providing appropriate incentives for firms to adopt responsible standards and checks and balances. To develop proper legislation, it is essential to understand the potential harms that may arise from the extensive use of AI technologies (Table 2).

Table 2. Potential harms of using algorithmic systems

Direct harm to consumers	• Price personalisation in a way that is opaque to the consumer; • Algorithmic systems can be applied for more comprehensive personalisation, enabling the manipulation of choice architecture or customer journeys on a broader scale; • Algorithmic discrimination; • Unfair ranking and design, including how algorithmic systems can be used to facilitate the preferencing of others for commercial advantage.
Indirect harm to customers	• Potential collusion by pricing algorithms: - Real-time data on competitors' prices and the use of automated pricing make it easier to detect and respond to price deviation; - Third-party software providers facilitate the exchange of information. - The possibility of autonomous tacit collusion. • Examples: IT software provider to Spanish real estate brokerage; online posters case; online travel agents' 'wide price parity' clauses.
Direct harm to competition	• Using algorithmic systems in exclusionary practices, dominant firms can take actions that deter competitors from challenging their market position. • Examples: self-preferencing (case of Google Shopping or Amazon Buy Box), manipulating ranking algorithms to exclude competitors (case of Google Search or Facebook News Feeds), and changing an algorithmic system in a gateway service that harms businesses that rely on it. • Predatory pricing.
Social harm	• Ineffective platform oversight harm. • Example: the harm caused by ineffective algorithms that are designed to combat fake online reviews; the harm caused by algorithms that are ineffective in filtering out harmful content.

Source: Competition and Markets Authority (2021).

On the consumer side, firms can leverage a wide array of consumer data to make inferences about their willingness to pay, enabling personalised pricing strategies. However, this data collection and utilisation may occur in ways that consumers neither expect nor have control over. Additionally, firms can employ machine learning and data science techniques to reduce customer attrition (or 'churn') by analysing customer characteristics or behaviours predictive of potential exit or switching. These churn models may then influence firms' decisions regarding price increases, renegotiation offers, and 'win-back' incentives. Such practices are perceived as unacceptable, especially if they result in vulnerable individuals paying higher prices.

Indirect harm to consumers relates to deployed algorithmic systems and the data that digital firms use and can change quickly as advancements occur. Algorithmic systems that interact with pre-existing sources of market failures may provide harmful results for society while proving highly profitable for participating firms. Although algorithmic collusion might not seem to be a significant problem now, it can become more pronounced if a substantial number of firms adopt increasingly complex algorithmic pricing systems through third-party solutions in a particular market.

In addition to potential collusion initiatives, another significant threat arises from the possibility of abusing dominant positions in the market, as outlined in Article 102 TFEU. This concern is often associated with the market positions of the largest platforms. Their algorithmic systems can greatly impact other firms that rely on the gateway platforms for their business. If algorithmic systems are not explainable and transparent, it may also make it increasingly difficult for regulators to challenge ineffective measures to counter harms. Without the right set of digital enforcement tools being developed internally or with the support of external parties, competition authorities may risk being left behind. They might fail to understand companies' algorithms that may infringe competition law or to understand how market players interact with each other in a way that is relevant for competition analysis. AI could help competition authorities enhance efficiency and accuracy and facilitate time-savings, avoiding lengthy investigations that may arrive at a favourable decision – at this point, it is already too late, and a particular remedy would no longer be useful.

In pursuit of their mission to create well-functioning markets that benefit consumers, businesses, and the economy, competition agencies, regulators, and policymakers must collaborate to adapt the scope of the law and refine their enforcement policies. As markets continue to evolve, new tools and capabilities will be essential to proactively prevent potential harm to competition and consumers.

5 Cybersecurity and AI

AI technologies have many applications in different sectors and industries. Among these, cybersecurity stands out as a critical sector that significantly benefits from implementing AI applications. Cybersecurity safeguards both citizens and society from harm caused by threats transmitted through computer networks. According to the literature, cyberattacks have become a new form of terrorist attacks on countries (Stevens, 2020). Global ransomware, the fastest-growing type of cybercrime, is expected to cause more than $265 billion in damage by 2031 and hit devices every two seconds (Braue, 2021).

In contemporary research, AI techniques have shown great promise in countering future cybersecurity threats. These techniques encompass a variety of intelligent behaviours, ranging from how machines can emulate human thinking to acting in a human-like manner (Zeadally et al., 2020). Recent AI-based cybersecurity solutions have mainly focused on machine learning methods, employing intelligent agents to distinguish between attack traffic and legitimate traffic. These agents function as human-like entities seeking the most effective classification rules. The technology has showcased that machine learning algorithms are better at providing security than humans (see Sharma et al., 2022, for anti-phishing techniques). Integrating artificial intelligence into cybersecurity ensures that errors are avoided. The key drivers pushing for increased cybersecurity at the corporate level include (1) a lack of cyber governance skills at the top management level, (2) the potential to utilise cutting-edge cybersecurity detection techniques, and (3) fragmented cybersecurity networks (Zeadally et al., 2020).

The future development in cybersecurity will revolve around four key aspects: (1) The Race Between Defence, Offense, and Humanity. AI's integration into cybersecurity involves three major stakeholders - offenders, defenders, and end users (humanity). Both offenders and defenders drive the advancement of AI techniques, making it challenging to delineate and regulate technological deployment. It is essential to explore how AI can cater to basic human needs and contribute to developing effective cybersecurity controls. (2) Infrastructure. The use of AI in cybersecurity is similar to a race between law enforcement and cyber attackers. The leading position is determined by access to technical knowledge and robust computing infrastructure. AI algorithms, being evolutionary in nature, demand considerable computational resources (Yousefi-Azar et al., 2017). (3) Hardware and Platform. Access to cutting-edge computing infrastructure is crucial for efficiently and effectively solving AI-related problems. With the increasing number of computing devices and data traffic, swift data analysis is vital (Gupta & Kulariya, 2016). High-end computing platforms, such as quantum computing, hold the potential to address complex computing challenges, with NASA's quantum computer demonstrating remarkable speed, being 100 million times faster than traditional computers. (4) Resources. The availability of necessary resources, particularly energy, is critical for implementing viable computing solutions. In the future, an ethical dilemma may arise concerning the allocation of scarce resources between intelligent computers and humans (Carter et al., 2018), which will prompt regulators to re-evaluate development priorities and basic needs.

Concluding remarks

Industry 4.0 technologies, including artificial intelligence and digitalisation, heralded a new fourth industrial revolution more than a decade ago, combining highly innovative solutions in the fields of physical capital, digitalisation and biology (Schwab, 2016; World Economic Forum, 2019). These new technologies have a great potential to accelerate economic growth, enabling the resolution of a wide range of challenges that will enhance individual well-being.

Artificial intelligence is expected to have many positive but also negative effects on the economy and society. AI falls within the context of Industry 4.0 technologies and the digitalisation of economies. Together, these new technologies are expected to present an opportunity to rapidly accelerate economic growth and development, increase the material and non-material wealth of citizens, and develop the modern welfare state. Thus, in the long run, technological progress has contributed as much as 63 percent of all productivity growth in the UK (Chadha, 2019). Firms adopt new technologies due to several factors: productivity and efficiency, process standardisation, quality improvement, shorter lead times, regulatory adjustments, revenue and sales growth, market share growth, new markets, horizontal and vertical integration, process improvements, government incentives, etc. (Čater et al., 2021). The introduction of new technologies translates into higher value added per employee and thus higher labour productivity, which in the long run leads to higher material welfare in society (Andulkar et al., 2018; Burda & Severgnini, 2018; JavaPoint, 2022; Lee et al., 2022; Tortorella et al., 2020). To understand the benefits and drawbacks of introducing new AI technologies in the business world, four business cases from four different industries are presented: an automotive company, a telecommunication company, a wholesaler and a digital advertising company.

However, unrestricted success in AI brings both immense risks and rewards. While the technical dimension of AI development explores the extent of system intelligence, it is crucial to shift focus towards socioeconomic factors. Various challenges have emerged, including issues of trustworthiness, privacy preservation, cybersecurity, social equality, policy and law, education, employment, and more (Jiang et al., 2022). Our research primarily focuses on legal aspects, cybersecurity issues and the labour market. Given the potentially serious consequences associated with regulatory decisions concerning AI, itecomes crucial to comprehend the public's long-term sentiments towards this technology. The discourse surrounding AI has experienced a significant surge since 2009, and overall, the prevailing sentiment has been consistently optimistic rather than pessimistic (Fast & Horvitz, 2017). However, certain concerns, such as the apprehension regarding losing control over AI, have increased in recent years. This trend was further accentuated after a letter signed by numerous prominent tech experts in March 2023 called for a temporary halt to AI research. The fourth part of the book delves into the comprehensive survey of public sentiments regarding AI, shedding light on the evolving perceptions and concerns surrounding this transformative technology.

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ARTIFICIAL INTELLIGENCE IN BRIEF: THE DEVELOPMENT AND IMPACT OF AI TECHNOLOGIES

Introduction

Artificial intelligence (AI) is expected to significantly impact the global economy in the near future (PWC, 2023). This chapter focuses on defining AI technologies, examining their economic consequences at the macro, industry and firm levels, and their broader social impacts, primarily in health, education, and environmental protection. Firstly, the context and development of AI technologies and how these can be classified will be examined. Secondly, the financial-economic impact, including the macroeconomic implications, will be explored, followed by the effects on important sectors such as finance, utilities, and others, and the short- and long-term benefits of adopting AI in organisations. Finally, broader societal consequences will be addressed.

1 Development of AI

AI may be described as a general term for computer systems that can detect their environment, reason, learn, and act in response to their perceptions and aims. Today's AI applications include machine learning, deep learning, chatbots, Natural Language Processing (NLP), and computer vision (PWC, 2023).

There are three main periods of historical development of AI. The first period (1950s – 1970s) was characterised by the foundation of most AI algorithms, including algebraic problem-solving, language translation, and geometric theorem proof. The second period (1970s – 1990s) was characterised by symbolic AI with "expert systems" aiming to encode human expertise as computer programs. The last period (1990s – 2020s) is marked by the development of machine learning, leading to the evolution of deep learning. AI's development has tackled intricate issues across various domains, leading today's AI revolution (Gungor, 2023). These advancements were made possible by developing other digital technologies serving as the bedrock for AI.

The development of AI is closely related to the development of digital technologies. Digital technology development began in the 1940s with the creation of electronic computers, the Electronic Numerical Integrator and Computer (ENIAC) and Atanasoff–Berry Computer (ABC). In the 1960s, microchips were introduced, leading to mass manufacturing of computers and electronic devices (McNeil, 1996). The 1970s saw the emergence of the Internet, e-commerce, email, search engines, and graphical user interfaces (GUIs). Computer graphics and multimedia technology enabled video games, digital entertainment, and virtual reality. Since the 2000s, smartphones, mobile devices, and cloud computing have increased connectivity and accessibility (Valenduc, 2018; Schwab, 2017).

The fourth industrial revolution began in the 2010s with cloud computing, social networks, electric vehicles, and advances in AI (Valenduc, 2018; Schwab, 2017). More recently, the 2020s have seen the continued development of advanced digital technologies such as AI, automation, robotics, 5G, Internet of Things (IoT), big data analytics, blockchain technology, and quantum computing (Roser, 2023). These advancements are serving as the bedrock for AI technology.

2 The classification of AI technologies

There are several classifications of AI. It can first be classified as weak, strong, or super. Weak AI or Artificial Narrow Intelligence (ANI) represents AI systems designed to perform specific tasks by simulating human behaviour within specific parameters and contexts. Strong AI or Artificial General Intelligence (AGI) refers to machines that can think like humans and execute any intellectual activity that a human can. Artificial Super-Intelligence (ASI) surpasses human intelligence in all aspects, understanding human feelings, beliefs, and desires (Kanade, 2022). Both AGI and ASI are hypothetical.

From a business perspective, AI technology can be classified based on the use case, with machine learning, neural networks and machine vision being the key areas that have revolutionised computers' capabilities (Khan et al., 2020).

Machine Learning is based on developing algorithms that enable computers to learn and make predictions or decisions from data (Goodfellow et al., 2016). It developed from simple algorithms in the 1950s to a dynamic discipline during the 1980s, employing neural networks, greater computing power and advanced algorithms (Khan et al., 2020). More recently, deep learning was developed, integrating neural networks with big data (Khan et al., 2020). Machine learning powers most AI applications but is predominantly used in data analysis, recommendation systems, and voice, image, and text recognition (Goodfellow et al., 2016). **Neural networks** were developed alongside machine learning from the early conceptual stages in the 1950s (Rajesh & Mohana, 2021). It reveals insights from sequential data, enabling machine vision and generative AI (Rajesh & Mohana, 2021). **Machine vision** was developed to enable computers to extract complex information from images or videos by combining machine learning with neural networks. It powers AI tools such as image identification and object detection (Kakani et al., 2020), commonly seen in autonomous vehicles, medical image analysis, and facial recognition (Szeliski, 2010).

Generative AI is designed to generate novel content in a multitude of forms, such as text, images, audio, video, code, simulations, or product designs (McKinsey, 2023). These models can learn from large datasets to generate coherent, relevant, innovative content. Generative AI powers the majority of automated content creation tools, modern chatbots and virtual assistants (McKinsey, 2023). **Text mining** involves the process of extracting valuable information and insights from large volumes of text data. It is used to analyse customer feedback, search engines, fraud detection and automated summarisation of documents (Manning et al., 2008). **Speech recognition** converts spoken language into machine-readable text or commands, which is behind virtual assistants like Alexa, transcription services and voice commands in smartphones (Young et al., 2006).

Robotic Process Automation (RPA) involves using AI and machine learning to automate repetitive tasks and decision-making processes. It automates "back-office" processes and data management (Jędrzejka, 2019; Lacity et al., 2015). **Autonomous systems** are machines or vehicles that can operate and make decisions without human intervention, relying on sensors, AI algorithms, and real-time data. They are used for transportation, warehouse and dockyard logistics, delivery, and robotics in manufacturing (Russell & Norvig, 2021). **Expert**

systems simulate the judgement and behaviour of a human with expertise and experience in a particular field. The technology is used in a growing number of fields, such as legal, medical and agriculture professions (Tan, 2017).

Future AI technologies are hoped to provide greater transparency, privacy and efficiency. For example, Explainable AI (XAI) aims to make AI models more understandable to humans by providing insights into their decision-making processes and increasing trust and adoption in areas such as medical treatment and self-driving cars (Linardatos et al., 2020). Federated learning will enable companies to create a shared global model without training data in a central location, bolstering privacy in fintech, the insurance industry and medical research (Khan et al., 2023). Finally, quantum AI is theorised to solve intricate problems currently infeasible for classical computers, accelerating R&D and optimisation across all industries (McKinsey, 2021).

3 Expected economic impacts of artificial intelligence

3.1 Expected macroeconomic impacts

The development and adoption of AI are predicted to contribute up to $15.7 trillion to the global economy by 2030, with China and North America as the biggest winners (PWC, 2023). China is expected to gain 26.1 percent, North America 14.5 percent, Northern Europe 9.9 percent and Southern Europe 11.5 percent from AI (Table 1).

Table 1. Increase of GDPs globally due to artificial intelligence by 2030

	GDP growth due to AI (%)	GDP growth due to AI (in trillion U.S. dollars)
China	26.10	7.00
North America	14.50	3.70
Northern Europe	9.90	1.80
Southern Europe	11.50	0.70
Developed Asia	10.40	0.90
Latin America	5.40	0.50
Rest of world	5.60	1.20

Source: PWC (2023).

North America is expected to see the fastest boost due to its openness and readiness (PWC, 2023), resulting from decades of leading R&D and investment in AI and advanced technologies (White House archives, 2021; HAI, 2021). GDP gains will be accelerated by consumer readiness for AI and the growing accumulation of assets in terms of advanced technology and data touchpoints, compounded by the exponential flow of information and customer insights generated by these technologies (PWC, 2023).

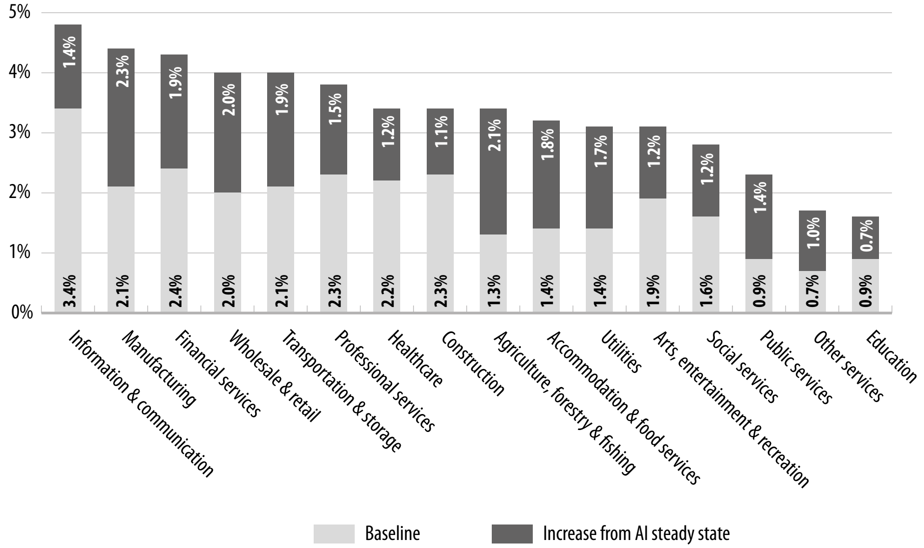
China's manufacturing-centric GDP is expected to experience GDP gains from advanced technology adoption by 2030 (PWC, 2023). However, building the expertise and assets needed to implement such technologies may take some time. Nevertheless, China has begun investing heavily in developing AI technologies and has recently demonstrated a surge in AI patents filed in China (HAI, 2021). Furthermore, China's high rate of capital reinvestment will result in increased AI capabilities, compounding potential returns (PWC, 2023). China also has a high adoption rate, as consumers are already exposed to AI technologies embedded in most consumer-facing apps and integrated into urban infrastructure (McKinsey, 2022).

The lower expected impact of AI on Europe's GDP is partly due to the limited AI diffusion and investment, with Europe utilising only 12 percent of their AI potential (McKinsey, 2019). EU companies are lagging behind North America in adopting key AI technologies such as big data analytics and machine learning. Nevertheless, Europe sees AI as a means of achieving the objectives of the European Green Deal, increasing sales, improving machine maintenance, and conserving energy (European Parliament, 2023). These objectives, coupled with Europe's strong AI developer workforce and competencies in robotics, could allow Europe to catch up with the United States regarding GDP impact (McKinsey, 2019; European Parliament, 2023).

3.2 Expected impacts in selected sectors

The impact of AI will vary by sector depending on the level of development of AI in that sector and how open the sector is to adoption. Figure 1 shows the very diverse impact AI will potentially have on the real gross value added (GVA) growth rates of various industries worldwide by 2035. The baseline is the growth rate without AI, and the steady state is the growth rate with AI integrated into the economy. Figure 1 further details the effects, while Table 2 summarises the main sectoral specifics.

Figure 1. AI impact on gross value added (GVA) growth rates by 2035, by industry



Source: Accenture (2017c).

3.2.1 Financial sector

AI is expected to have the most significant impact on finance (PWC, 2023), with 4.3 percent of the growth in this sector coming from AI by 2035 (Accenture, 2017a). The fintech market is projected to see growth from generative AI of 22.5 percent by 2032 (Nguyen, 2023). Three key areas of finance with the greatest potential for transformation are personalised financial planning, process automation, and fraud detection and anti-money laundering (PWC, 2023). Due to a broader and deeper analytical basis, better prediction and characterisation of consumers has already begun, improving the quality and relevance of products and services (Bredt, 2019). However, AI in the financial sector can enhance efficiency but also poses risks like pricing discrimination, opaque decision-making, privacy concerns, overreliance, exclusion, bias, and cybersecurity risks. Complex AI systems can cause mistrust and confusion, while overreliance can lead to errors and fraud. Clear guidelines and robust data protection measures are needed (Ryzhkova et al., 2020). AI breakthroughs in virtual assistants have made it possible to provide tailored investing solutions for mass-market customers at affordable prices, a service formerly reserved for high-net-worth clientele (Murugesan & Manohar, 2019).

AI is predicted to increase efficiency and lower costs in fraud and criminal behaviour detection and anti-money laundering (Bredt, 2019; EY, 2023). AI models are currently reducing insurance compensation overpayment and assisting banks in anticipating defaults on loans (Latinne, 2023). AI-enabled financial fraud detection and prevention platforms have already generated total cost savings of $2.7 billion globally in 2022, while future savings are expected to total $10.4 billion by 2027 (Zeitgeist, 2023).

Robotic Process Automation (RPA) is expected to transform back-office operations into mostly automated tasks (EY, 2023). This change would streamline workflows, increase efficiency, and decentralise routine operations such as remittance, tax, or bill payments without employees (Met et al., 2020). RPA will also optimise customer-facing operations, automating front and back operations and simplifying the work of account managers (EY, 2023).

3.2.2 Mining and quarrying, manufacturing and construction industries

Advancements in AI technology are transforming mining, manufacturing, and construction sectors, promoting safer, more efficient, cost-effective, and environmentally responsible practices (Lamelza, 2023). The market size of AI in manufacturing is projected to reach $9.89 billion by 2027 (Fortune Business Insights, 2020) and generate annual savings of $290–$390 billion in mining by 2035 (The Oregon Group, 2023). AI is improving industry safety by using computer vision to assess accidents and enhance safety measures (Ellis, 2023), whilst electric mining tools, like AI industrial swarm robotic mining systems, are replacing workers in hazardous conditions (Cossins-Smith, 2023). AI-powered predictive maintenance enhances manufacturing efficiency by forecasting equipment and material failures, pre-emptively scheduling maintenance, and reducing machine failure costs. Machine learning algorithms in generative design software enable designers to explore diverse design outputs based on input parameters (Dilmegani, 2023). Digital twins aid manufacturers in comprehending products, testing performance improvements, and monitoring the object's lifecycle, providing alerts for maintenance needs (Marr, 2021). Robotic Process Automation (RPA) streamlines repetitive tasks, including data transmission, computations, and order processing, minimising manual data entry errors. Machine vision cameras are used to detect errors accurately, surpassing human capabilities. Collaborative robots, known as Cobots, learn tasks and work alongside humans, assisting with dangerous work (Moore, 2023). Metaverse technology, including Virtual Reality and Augmented Reality, enhances staff training and product design, resulting in fewer accidents and greater efficiency (Marr, 2023). Industry efficiency is increasing with Blockchain technology, which optimises delivery times and eases customs clearance for materials (Marr, 2023).

Building Information Modeling (BIM) is revolutionising project planning, design, and management (Dehghan, 2023). Predictive models create realistic project timeframes, and self-driving construction machinery does repetitive tasks (Rao, 2022), while machine learning algorithms improve supply planning and inventory management (Dilmegani, 2023).

Cost-effectiveness has been improved using Neural Networks for Predictive Maintenance, which anticipate equipment problems, while autonomous vehicles reduce operating costs (Corrigan & Laye, 2022). Finally, AI-based sorting systems maximise mineral extraction, cutting costs by reducing waste (Marr, 2021).

3.2.3 Utilities

Machine Learning (ML), the Internet of Things (IoT), predictive analytics, and grid management systems are playing pivotal roles in transforming utilities in the water supply, sewerage, waste management, environmental remediation, and energy sectors (Tanveer et al., 2022). In the energy sector, AI is improving efficiency, reliability, sustainability, and customer service. It accurately predicts energy demand, optimises power generation and monitors real-time equipment condition. AI-driven systems manage supply, demand, renewable energy integration, grid stability, and customer engagement while also predicting generation patterns and adjusting production accordingly. As these industries evolve, AI technologies will become increasingly crucial for efficient, reliable, and environmentally friendly energy services (Sai Ramesh et al., 2023). Green hydrogen, a completely carbon-free fuel, is set to become a real contender to revolutionise the energy market. Neural networks, machine learning, support vector regression, and fuzzy logic models support hydrogen energy production, storage, and transportation (Sai Ramesh et al., 2023).

In water supply, sewerage, waste management, and environmental remediation, AI is optimising operations through predictive maintenance and efficient resource management (Moni et al., 2021). AI technologies can optimise operations, predict maintenance, manage resources, monitor environmental conditions, aid waste sorting and recycling, and ensure compliance with environmental regulations. They also contribute to public health and safety by minimising contamination risks and ensuring reliable, clean water delivery. Key future trends include smart infrastructure, water recycling, decentralised systems, energy efficiency, waste-to-energy, circular economy, and environmental remediation. AI-driven processes, public engagement, regulatory compliance, and climate change resilience will play crucial roles. Decentralised systems, renewable energy, and advanced AI modelling will further enhance resilience and efficiency (Moni et al., 2021).

3.2.4 Transportation and storage services

Increasing adoption of AI automation, AI-powered forecasting and advancements in real-time data are revolutionising transportation and storage services. Deep learning, computer vision, and NLP are already used in autonomous vehicles, which are expected to improve road safety, reduce costs, and lower emissions (Stefano, 2022). The IoT allows real-time monitoring of vehicles and assets, providing information on location, status, and condition, which enables logistics firms to optimise route planning, minimise fuel consumption, reduce idle time, and reduce failures through predictive maintenance (Smith, 2023). AI-driven demand forecasting can predict product demand across supply chains by analysing market trends and historical data, helping logistics managers optimise inventory levels, reduce holding costs, and coordinate operations to meet customer demands. AI algorithms can also assess real-time data, such as storage conditions and order fulfilment status, to optimise warehouse operations, including efficient layout design and automated inventory management, enhancing efficiency and client satisfaction (Smith, 2023). AI algorithms optimise warehouse operations by analysing real-time storage conditions and order fulfilment to create efficient layout designs. Furthermore, automated inventory management and intelligent picking and packing are increasing efficiency (Smith, 2023). Autonomous driverless vehicles, trucks, and drone ships are expected to revolutionise freight transportation (Gordon, 2021), while AI-powered drone taxis will improve urban infrastructure and transit (Chipilska, 2023).

3.2.5 Information and communication services

Machine learning, NLP and deep learning are improving ICT services by enhancing the performance of communications, digital commerce and apps, supporting information and communication accessibility (Zalar et al., 2023). NLP can process human communication for machines to understand communications delivered in human language, allowing for innovations in apps and communications tools (Guzman & Lewis, 2020). Data from social media can be collected and analysed by AI, providing a competitive advantage to organisations (Thakur, 2021). AI also addresses data security challenges (Koman et al., 2023; Gorišek et al., 2023). Furthermore, AI is aiding the development of information systems through a pre-designed collection of developer algorithms generating bug-free codes, reducing development times. Hereafter, the expansion of AI-powered tools, such as virtual assistants and chatbots in information and communication services, is expected to increase connectivity and service availability (Paul, 2023).

3.2.6 Retail and consumer impact

AI has significantly impacted the retail industry, benefiting both retailers and consumers. Retailers leverage AI to optimise inventory management, accurately forecast demand, streamline supply chains, and fine-tune pricing strategies. This optimisation leads to cost savings, quicker delivery times, competitive pricing, and personalised marketing campaigns (Lokanan, 2023). Machine learning analysing customer behaviour allows for tailored marketing and store optimisation, enhancing engagement and loyalty (Murf, 2023).

Consumers are experiencing a more personalised shopping experience with AI-driven recommendations, chatbots, and virtual assistants, which enhance convenience and customer service. Price comparison tools, AI-based surveillance systems, and AI-powered checkout systems improve transparency, security, and payment efficiency. Additionally, AI enables virtual trial and fitting rooms, reducing returns and increasing customer satisfaction. Nevertheless, as AI technology continues to advance, both retailers and consumers should be mindful of data privacy, security, and potential job displacement issues while capitalising on the benefits AI brings to the retail industry (Guha et al., 2021).

3.3 Firm-level impacts

In the short term, AI is expected to improve efficiency, costs, quality, traceability, productivity, flexibility, sales, profitability, return on assets (ROA), reduce inventories, and simplify documentation (WEF, 2020). AI serves as a foundational component, optimising routine tasks, facilitating informed decisions, and fostering autonomous system and process development (WEF, 2020). Regarding productivity, with AI technologies, support agents could handle 13.8 percent more customer inquiries per hour, business professionals could write 59 percent more business documents per hour, and programmers could code 126 percent more projects per week (Nielsen Norman Group, 2023). Depending on the sector, AI's interconnectedness enables seamless communication and collaboration across industries (Schwab, 2017).

Table 2. The impact of artificial intelligence on sectors today and future expectations

Sector	Current key AI technologies	How/why is AI important today	Future expectations
Mining and quarrying, manufacturing and construction	Machine learning, neural networks, predictive models, autonomous vehicles, AI-based sorting systems, digital twins, generative design, robotic process automation, computer vision, building information modelling and self-driving machinery.	Real-time data collection and analysis improve efficiency and safety by generating forecasts, allowing for anticipated maintenance, and reducing costs, supply planning, inventory management, and project planning.	The integration of electric mining tools, autonomous robots, drones, metaverse, virtual and augmented reality, blockchain, AI-powered robots, and automation.
Utilities	Machine learning, IoT, predictive analytics, grid management, chatbots, neural networks, support vector regression, and fuzzy logic models.	Enhance efficiency, reliability, sustainability, customer service, reducing costs and improving the overall quality of services provided to communities.	Renewable energy integration, grid modernisation, energy storage, electrification, energy efficiency, customer-centric services, smart infrastructure, water recycling, waste-to-energy, data analytics, public engagement, and regulatory compliance.
Finance	Process automation, AI modelling, machine learning, chatbots, robo-advice, natural language generation.	Massive reductions in process costs and time, new tools to combat criminal financial behaviour, and methods to increase modern financial literacy.	AI financial advisors, complete back-office automation.
Transportation and storage	IoT, deep learning, computer vision, NLP, AI-driven demand forecasting.	Real-time monitoring of vehicles and assets, road safety, saving costs and lowering emissions, optimising inventory levels and warehouse operations, and reducing holding costs.	Autonomous driverless vehicles, drone ships and drone taxis.
Information and communication	Machine learning, natural language generation, deep learning, NLP.	Enhances communication performance, useful in data security challenges, efficiency in information dissemination and communication.	Expansion of AI-powered tools such as virtual assistants, conversational AI, and chatbots.
Retail	Machine learning, chatbots, virtual assistants, price comparison tools, AI-based surveillance systems, and AI-powered checkout systems.	Inventory management, forecast demand, cost savings, quicker delivery times, competitive pricing, personalised marketing campaigns, transparency, security, payment efficiency, reducing returns, and customer satisfaction.	Mindful of data privacy, security, and potential job displacement issues while capitalising on the benefits AI brings to the retail industry.

Source: Own work (2023).

In the long run, incorporating AI technologies can give a company a competitive edge through cost reduction or workflow optimisation. DUKAAN, an e-commerce start-up, replaced 90 percent of its support staff with an AI chat box, reducing service costs by 85 percent (BBC India, 2023) and making it more efficient than its competitors. Using machine learning with predictive marketing, companies can also increase their market share through tailored products and services that meet specific customer needs (Marr, 2019). Amazon and Alibaba are known for their AI-powered recommendation system. By analysing user behaviour and purchase history, both e-commerce giants' recommendation engines suggest products that customers are likely to be interested in (Marr, 2019). Thirty-five percent of what consumers purchase on Amazon comes from product recommendations based on these machine learning algorithms (Morgan, 2018). Customers also stay on the Amazon site longer due to the personalised experience, which boosts sales and consumer loyalty (Marr, 2019).

Leveraging AI and predictive analytics has enabled companies to anticipate customer expectations and offer aligned customer experiences, improving satisfaction and customer loyalty (Verma et al., 2021). Starbucks introduced its AI-powered loyalty program that uses preferences and purchasing behaviours to offer personalised rewards. The mobile app suggests personalised drink choices and offers discounts based on individual preferences, enhancing loyalty and repeated visits (Hyperwrite, 2021).

Innovative AI-centred business models are being developed (Lee et al., 2019). A cement production company placed AI at the centre of hiring practices, illuminating problems with recruitment speed and accuracy and subsequently enabling the design of a more efficient talent management approach (Lee et al., 2019). Such new AI approaches are hard to replicate. For instance, Google search now involves many different AI technologies, such as image and speech recognition, predictive search results, and smart advertising (Marr, 2019). This applied collection of AI technology provides a unique and high-value service that is difficult for competitors to imitate (Marr, 2019). Finally, AI's ability to process and analyse vast amounts of data in real time has led to insights and precision that were unattainable with conventional technologies (Karunathilake et al., 2023).

4 AI systems, people, and planet

4.1 Healthcare

Chatbots and virtual assistants relieve administrative burdens on healthcare providers, offering a convenient alternative for patients to access services. These AI-driven technologies provide patients with 24/7 access to healthcare information, answer medical queries, and assist with appointment scheduling (Teo, 2022). For example, virtual nurses save 20 percent of real nurse time by avoiding unnecessary visits (Accenture, 2017b).

AI in radiology has resulted in more efficient workflows, shortened reading time, reduced dose and contrast agents, and improved personalised diagnostic accuracy, leading to reduced costs and increased healthcare quality (van Leeuwen et al., 2022). In other fields, AI has been used to identify abnormalities, tumours, and other medical conditions with high accuracy (Kumar et al., 2023), diagnose liver disease (Ansari et al., 2011), and predict coronary heart disease (Gonsalves et al., 2019). In the US alone, these AI technologies are expected to generate $150 billion in annual savings by 2026 (Accenture, 2017b).

AI is also improving treatment by analysing genomic data, identifying genetic mutations, and illuminating implications for disease risk. This contribution enables personalised treatment plans tailored to an individual's genetic makeup (Quazi, 2022). The drug development process has been accelerated by using AI to analyse biological data to simulate the interactions of molecules and identify potential drug candidates, cutting costs and making innovative therapies more accessible to all patients (Paul et al., 2021).

4.2 Education

AI systems are revolutionising education by providing personalised, adaptive learning, enhanced evaluation, language learning and translation, customised educational content, and early intervention. AI-powered online platforms have increased global access to education by providing access to lectures and study materials from top institutions. AI automation can create personalised educational content like textbooks, quizzes, and practice exercises, reducing time and aligning content with instructional objectives. AI may help with professional development by identifying areas that need more training and early intervention, as well as identifying students who are at risk of falling behind (Holmes & Tuomi, 2022).

To ensure the appropriate use of AI in education, however, ethical concerns concerning data privacy, bias in algorithms, and possible monitoring in online learning settings would need to be addressed (Holmes & Tuomi, 2022). To ensure that AI serves the best interests of children and educators, it is necessary to balance the benefits of AI with ethical and equity issues (Chace, 2020).

4.3 Environmental protection

AI is used in air purifiers, computer systems, and simulation systems to assess air quality, activate filtration processes, and warn residents about pollution levels. AI-driven simulation systems for urban and rural areas (Wayne et al., 2023) provide real-time information on air quality impact and health protection strategies (UNEP, 2022). Machine learning technologies improve grid system efficiency, incorporating smart sensors to optimise energy consumption in buildings (Wayne et al., 2023).

AI can also be used to monitor and reduce emissions, potentially reducing global greenhouse gas emissions by 5 to 10 percent by 2030. This can be done by optimising carbon-free energy production, traffic management with autonomous vehicles, and predicting maintenance needs (UNEP, 2022). AI and proactive machine learning, combined with satellite imagery, are also crucial in monitoring Earth's land, safeguarding against natural disasters, and addressing biodiversity conservation (Wayne et al., 2023).

Conclusion

The continued development of AI technologies has recently reached a tipping point of mass adoption as organisations begin to understand the power and usefulness of AI tools. Contemporary AI encompasses several areas that can benefit companies in the modern business environment. Key technologies such as machine learning, neural networks, and computer vision are already reshaping industries and services across the globe. The macroeconomic impact of AI is expected to be profound, potentially contributing $15.7 trillion to the global economy. However, only countries most prepared and open to AI are expected to benefit the most, such as the USA and China. Across various sectors, AI is driving significant changes. In finance, it is revolutionising financial planning, back-office processes, and fraud detection. Industries like mining, manufacturing, and construction are benefiting from enhanced efficiency, safety, and sustainability. Utilities are optimising operations, and transportation and logistics are reaping the benefits of real-time data analysis and autonomous vehicles. In the short run, AI adoption offers immediate advantages at the firm level, including improved efficiency, cost reduction, and enhanced decision-making in various industries. In the long run, AI provides a competitive edge, enabling companies to customise products, services, and customer experiences, fostering loyalty, and driving innovation in business models. AI's impact extends to society and the environment as well. In healthcare, it streamlines administrative tasks and elevates diagnostic accuracy. In education, society benefits from personalised learning and administrative automation. AI contributes to environmental protection by monitoring pollution and reducing emissions. Nevertheless, it is important to address ethical and privacy concerns and to use AI responsibly to maximise the benefits of AI.

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ADOPTION OF AI TECHNOLOGIES AROUND THE WORLD

Introduction

Artificial intelligence (AI) is increasingly used in businesses worldwide, and its popularity continues to grow. Recently, there have been massive investments in AI. Companies are researching and adopting best practices for using AI to achieve their goals. As a result, it has the potential to revolutionise the way people innovate, conduct and organise business and impact all areas of the economy (Lee et al., 2022).

Although AI is used worldwide, adoption varies across countries/regions. The global generative AI market, estimated at $1.75 billion in 2022, is expected to develop rapidly at a compound annual growth rate (CAGR) of 79.9 percent, reaching $33.03 billion by 2027. In 2022, North America led the market with 34.4 percent of the market share. Asia-Pacific and Western Europe followed in second and third place, with market shares of 33.1 percent and 17.2 percent, respectively. These regional variations represent different goals and opportunities for AI adoption (GlobalData, 2023). In addition, industries such as healthcare, the automotive industry, banking, financial services, insurance, retail, and agriculture are increasingly turning to AI to improve customer relationships and productivity (Zinchenko, 2023).

In the current state of AI research, inherent limitations persist. Data collection lacks standardisation, making comprehensive assessments challenging. Quantifying AI, with its broad scope, remains complex, leading researchers to rely on indirect methodologies such as approximations. For instance, in this research, AI job opportunities were studied through job postings, which can be imprecise, as many positions are filled unadvertised. Thus, it is essential to approach this study with caution, recognising potential data reliability issues due to these challenges.

This chapter focuses on (1) the stages of AI adoption across regions, (2) a comparative analysis of regions, (3) and a comparison between industries. The chapter begins with the methodology section, where the process of data collection and the statistical methods used are explained. Then, a detailed comparison between Asia, Europe, North America, Oceania and South America follows with respect to selected AI indicators. The third section compares the different industries, followed by a comprehensive conclusion that addresses the three theoretical questions.

1 Methodology

AI requires a comprehensive approach to collecting AI-related data and analysis from various high-quality sources. The data was provided by the AI Lab of Slovenia's Institute "Jožef Stefan" (hereafter IJS). The IJS collects the data from a variety of sources, including AI news from Event Registry, AI research data from Microsoft Academic Graph and Elsevier (Scopus), information on AI jobs and skills from LinkedIn and Adzuna, and AI investment data from Preqin (OECD.AI, 2023c). Additionally, the data was organised, cleaned, and aggregated using RStudio statistical software.

Table 1. List of regions and subsequent countries used in the analysis

Region	Countries
Asia	China, India, Japan, Korea, Malaysia, Russia, Singapore, Taiwan, and Vietnam
Europe	Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom
North America	USA, Canada
Oceania	Australia, New Zealand
South America	Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Uruguay

Source: Own work (2023).

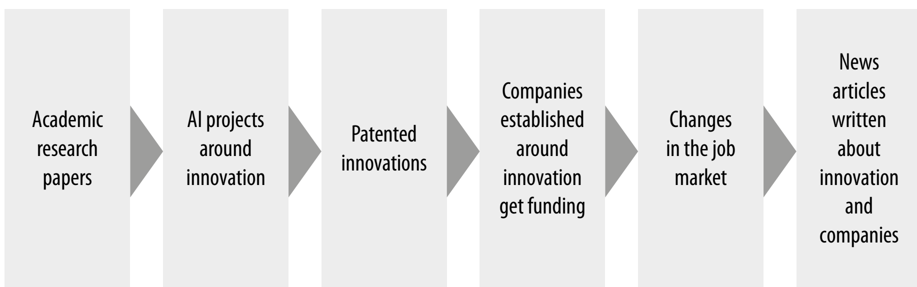
The following indicators were analysed: AI-related scientific papers, AI-related citations from research papers, AI-related software projects, AI-related patents, AI-related funding, AI-related job postings, and AI-related news. The primary raw data were available on a monthly basis, which was later aggregated annually for the period from 2010 to 2022. In addition, for AI-related news, the time frame covers 2014 to 2022 inclusive; for jobs, data begin in 2017; and for patents, data are available only through 2021. For this analysis, regions with selected countries were formed (Table 1).

To enrich the demographic context, the data from the World Bank dataset (2023) was integrated to provide demographic insights (population). For subsequent subject-level analysis, the data were normalised so that the numbers were proportional to a per capita value of one million inhabitants. This normalisation procedure was performed to allow for a clear and intuitive comparison and interpretation of the results and to eliminate the size effect or bias. In conducting the industry comparison analysis, the total sum of data from all countries was separated into different industries. Additionally, some data was used directly from the Organization for Economic Cooperation and Development (OECD) website.

2 Comparison of Asia, Europe, North America, Oceania and South America

This section uses selected indicators to compare how AI is adopted in key regions of the world. The order of analysis follows the indicators through the stages of innovation (Figure 1). Typically, the first signs of an innovation arise from scientific research that leads to related projects and eventually results in the patenting of the innovation. Subsequently, businesses are created, and investment is attracted, resulting in job creation. As the innovation progresses, the market responds, and news articles are often published on the topic (Grobelnik, 2021).

Figure 1. Main AI indicators through innovation stages



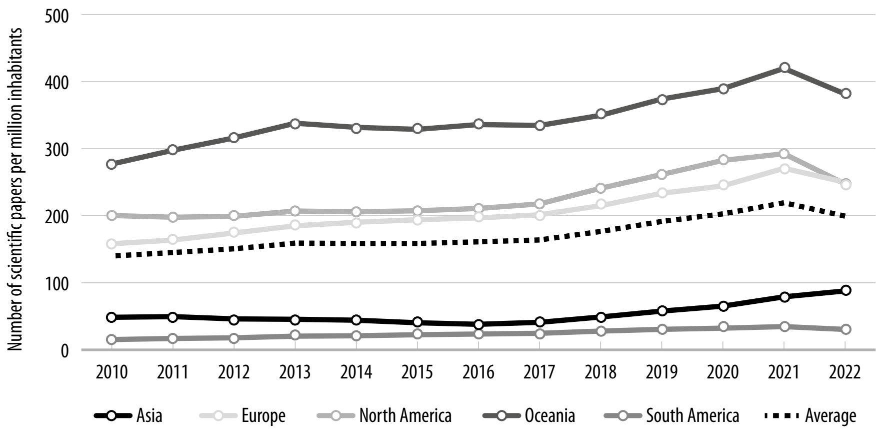
Source: Grobelnik (2021).

2.1 Research in AI

In general, academia often serves as an early indicator of future innovation (Grobelnik, 2021). Therefore, it is important to analyse both the quantity and quality of academic papers on AI to understand the starting point for AI development in each region.

Europe and North America have relatively similar scientific output, with about 200 publications per million population (Figure 2). North America was ahead of Europe for most of the studied period, but Europe overtook North America in 2022. Interestingly, Oceania had the highest output of scientific papers per million inhabitants. In addition, Asia was below the average (represented by the dashed line), which was not expected since Asia is home to some of the leading countries in scientific research, such as China, Japan and Singapore[1] (Daitian et al., 2021). However, when looking at the normalised data (per million inhabitants), Singapore leads the Asian region by far.

Figure 2. Number of AI-related scientific papers per million inhabitants by region from 2010 to 2022



Note: The dashed line represents the yearly average of scientific papers across all regions. n 2022, the data source was changed (from MAG to OpenAlex with slightly different coverage).

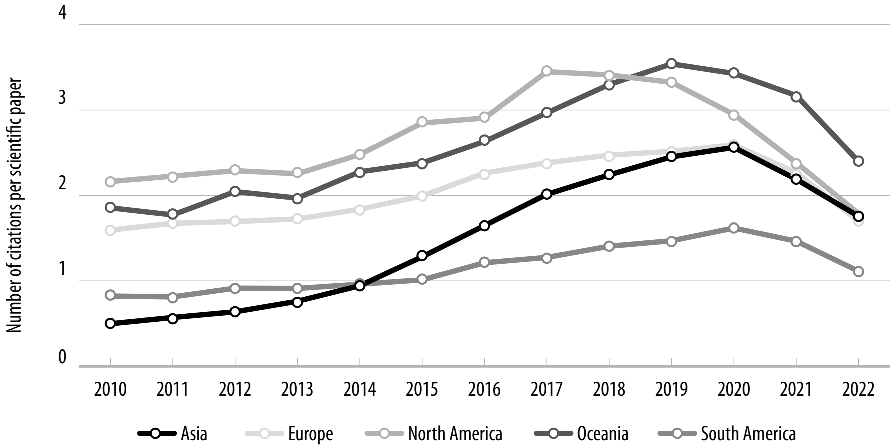
Source: IJS Data using Mag/OpenAlex (2023), World Bank (2023).

Additionally, as opposed to the source cited in the introduction stating that Asia-Pacific claims a 33.1 percent market share (GlobalData, 2023), this analysis separates Asia-Pacific into Asia and Oceania. It normalises the data to 'per million inhabitants'. As a result, the findings differ from each other.

1 If only China, Japan and Singapore were included in the region of 'Asia', they would still remain below the average of normalised data.

The quality of research is measured by the number of citations. To analyse regional differences, the number of citations per scientific paper is compared. North America had the highest quality scientific output from 2010 to 2018 (Figure 3). Despite Oceania having a substantial lead in the number of scientific publications during this period, it did not surpass North America in terms of citations per scientific paper, which might be expected given its higher publication volume. After 2018, Oceania regained its lead.

Figure 3. Number of annual citations per scientific paper by region from 2010 to 2022



Note: The citations take a few years to build up, hence the drop in the most recent years. In 2022, the data source was changed (from MAG to OpenAlex with slightly different coverage).

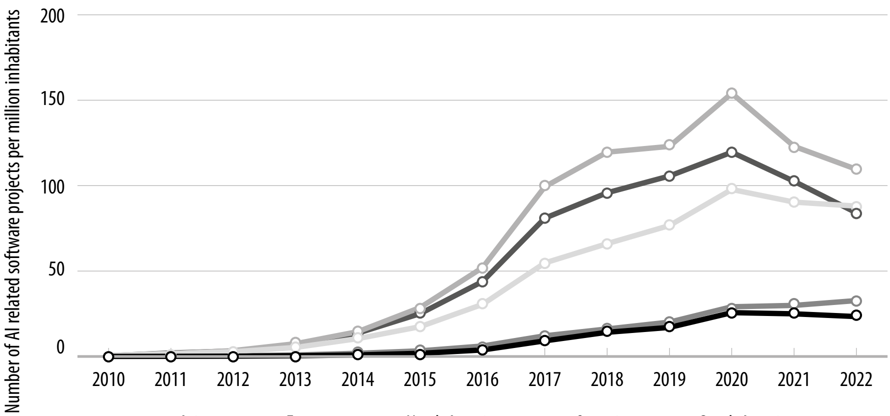
Source: IJS Data using Mag/OpenAlex (2023).

Throughout the period, Europe was in third place. In the beginning, it was closer compared to the two leaders, but after 2017, the gap has widened. Although the number of scientific papers is lower, Asia has caught up to Europe regarding the number of citations per scientific paper. South America still has the least impact in the scientific field of AI.

2.2 AI-related projects

When the subject is sufficiently researched, projects on the subject are launched. North America leads the way in AI-related software projects during the period studied (Figure 4). Most of the major technology companies are from the US, which, combined with the strong innovation ecosystem supported by strategic investments, makes the US a global leader in AI (Parker, 2020). For most regions, 2020 appears to be the peak of AI-related software projects per million population; after the outbreak of COVID-19, this number seems to be declining. In addition, South America appears to be overtaking Asia, contrasting other indicators discussed in this chapter.

Figure 4. Number of AI-related software projects per million inhabitants by region from 2010 to 2022

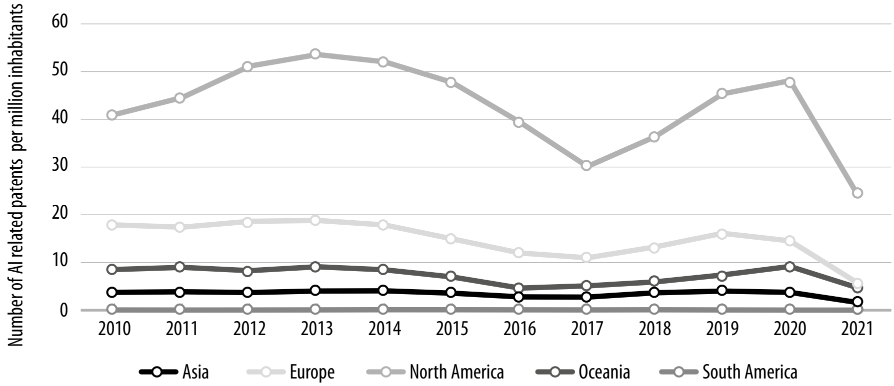


Source: IJS Data using Github (2023), World Bank (2023).

2.3 AI-related patents

While projects can show how much progress is being made, the number of patents reveals where the new ideas are coming from. Therefore, this indicator is important when it comes to AI adoption around the world. North America leads the regions in the number of patents per million population (Figure 5), which is to be expected, as most of the major technology companies involved in AI development come from the US. Europe is second, but similar to the other regions, far behind North America. A certain cyclicality of patent output can be observed (a decline in 2017). This cyclicality can be attributed to the diversity of patents and the corresponding timing of technological progress, as has been confirmed by other researchers in the field (see, e.g., Leydesdorff, 2015). After 2020, the number of patents per million inhabitants has declined in all regions. In North America, the number of patents per million inhabitants has halved, from 48 in 2020 to 24 in 2021. However, as no definitive evidence indicates an end to a patent cycle, this decline could also be a consequence of the pandemic.

Figure 5. Number of AI-related patents per million inhabitants by region from 2010 to 2021

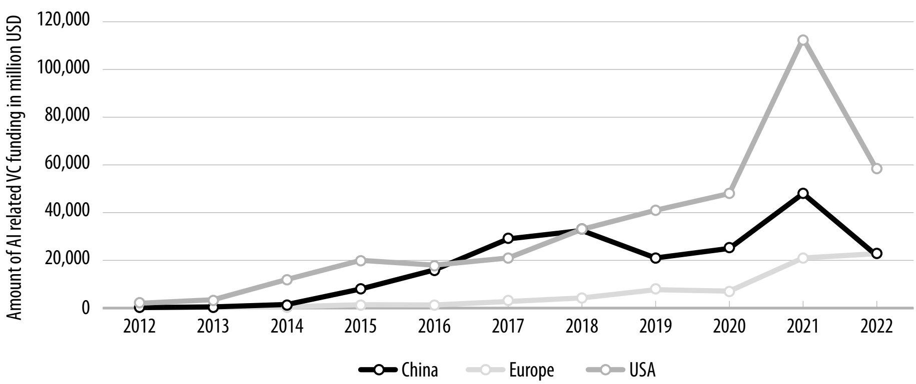


Source: IJS Data using Github (2023), World Bank (2023).

2.4 Funding in AI

As in all fields, funding plays a critical role in AI adoption. It drives the research that leads to important discoveries, attracts people to work on AI, and turns innovation into reality. For the analysis, a distinction is made between government funding and venture capital funding (hereafter VC). In Europe, government funding is more important due to the less developed VC infrastructure, while the United States and China rely more on VC funding (Duten, 2021).

Figure 6. Amount of VC funding related to AI in million USD, by country/region from 2012 to 2022



Note: Europe consists of the EU-27 countries and the United Kingdom. Other countries and regions were mostly irrelevant; therefore, the focus was to compare the two leaders to Europe.

Source: IJS Data using Github (2023).

In recent years, Europe has increased its AI-related VC funding and is slowly catching up with China (Figure 6). The United States is the clear leader here. It has the most developed VC infrastructure with the most investments globally, while China follows in second place (Dealroom, 2023). The sharp increase in funding in 2021 was related to the global increase in VC spending due to the impact of 2020 and the pandemic (TrueBridge Capital, 2022).

In 2021, venture capital investment in North America and Europe experienced a remarkable upswing, more than doubling from the previous year. In particular, the European investment landscape saw extraordinary growth of 135 percent compared to 2020. This global trend has benefited start-ups worldwide as investors increasingly explore international opportunities for their next ventures. The upswing in funding has translated into rising valuations and significant amounts of investment, as evidenced by the ever-growing number of unicorn companies entering the market year after year, many of which are AI-related (Factset, 2022).

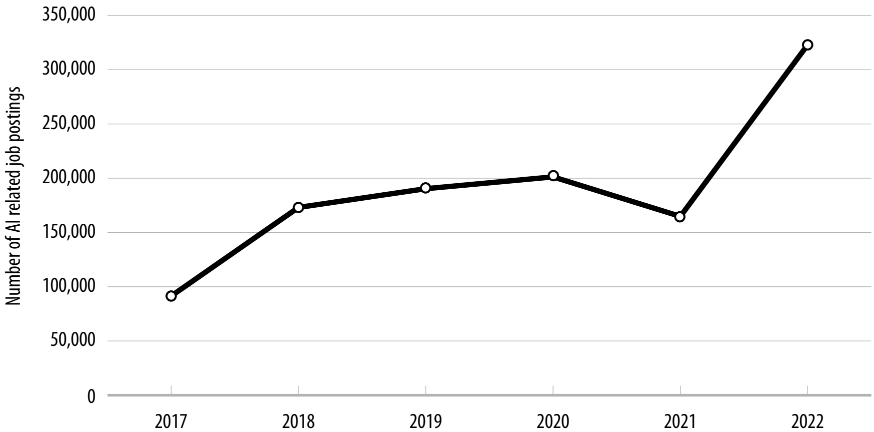
The data largely included funding for AI projects supported by the European Union (hereafter EU). Therefore, only government-supported funding for Europe and not for the other regions is analysed. The EU aims to develop and invest in AI because it believes it can bring significant improvements to society (European Commission, 2023). The general trend has been for funding to increase each year, except for a drop of more than 30 percent in 2013 and 2014. After those years, funding increased again, much more so than in the early years of the monitoring period. From 2015 to 2021, government AI funding in Europe had an average annual growth rate of 40 percent, reaching €1.35 billion by 2021. When both VC and government funding in Europe are added together, the region still lags far behind funding in the US. For 2022, Europe shows a combined production of $22.9 billion, while the US reaches about $58 billion in VC production alone.

2.5 AI-related job postings

The number of AI-related job postings can directly inform us about the development of AI technologies in the economy (Grobelnik, 2021). Although the analysed data do not include all countries from the previous analyses, nor do they cover the entire period from 2010 to 2022, they give us a general idea of industry trends. Over the period from 2017 to 2022, the number of job openings in the AI industry recorded an average annual growth rate of 30.3 percent (Figure 7), with most of this growth occurring in 2022 in all regions except

Europe, where growth was highest in 2018. In 2022, job postings almost doubled from the previous year, increasing by 95.9 percent. The year before, there was a decrease of 18.1 percent, which can be attributed to COVID-19 and its impact on the labour market. Disregarding the year 2021, due to the impact of the pandemic, there is a general upward trend, which indicates that the number of vacancies in the field of artificial intelligence is increasing and will most likely continue to rise in the future.

Figure 7. Total number of AI-related job postings in selected countries from 2017 to 2022



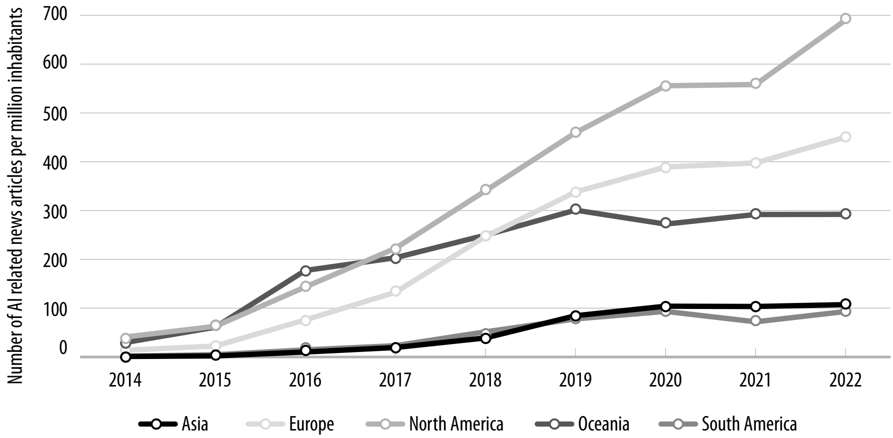
Note: The data includes the following countries: Australia, Austria, Brazil, Canada, Germany, France, India, Italy, the Netherlands, New Zealand, Poland, Russia, Singapore, South Africa, the UK and the USA.

Source: IJS Data using Github (2023).

2.6 AI-related news

Previously discussed innovation indicators require sufficient development to communicate the topic to the general audience, which is why media coverage is one of the final indicators (Grobelnik, 2021). North America ranks first in AI-related news articles per million inhabitants. Europe is not far behind, as both North America and Europe seem to be heading in the same direction. The trend in these two regions regarding the number of AI-related news articles has increased yearly since 2014 (Figure 8), suggesting that the topic will remain relevant. Asia and South America have performed similarly for most topics discussed, which is also true for the number of AI-related news articles per million inhabitants, ranking below the average. In addition, until 2018, Oceania reported more on this topic than Europe. After 2018, the number of AI-related news articles per million inhabitants stagnated, and Europe overtook the region.

Figure 8. Number of AI-related news articles per million inhabitants by region from 2014 to 2022



Source: IJS Data using Github (2023), World Bank (2023).

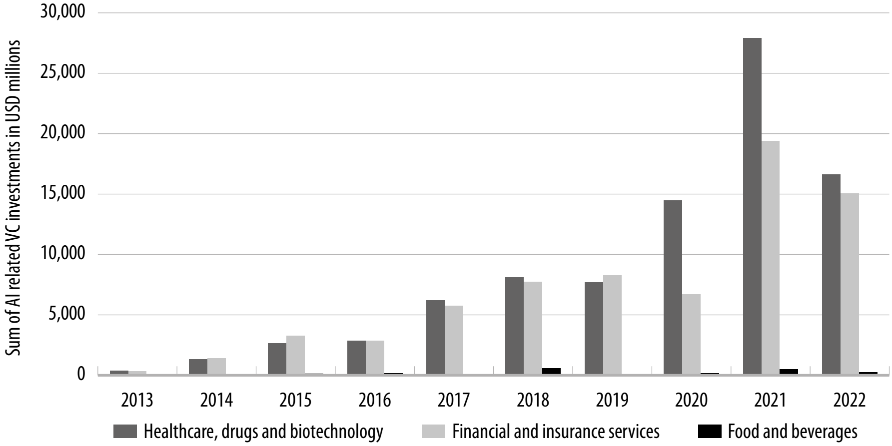
3 Comparison of industries

AI is expected to significantly impact all industries, with healthcare, banking, retail, and consumer goods among those that could experience substantial value growth (Chui et al., 2023). Therefore, the analysis will emphasise the three industries: healthcare, financial and insurance services and consumer goods. Technology holds great promise for healthcare by improving diagnostic accuracy, faster drug development and personalised treatments. On the other hand, in the banking, retail and consumer goods sectors, customer satisfaction may be enhanced by personalised services and products (see also Redek et al., 2023). Furthermore, the study will address venture capital investment and explore other relevant factors pointing to the importance of AI adoption.

3.1 Venture capital investments in AI by industry

Looking at the specific focus on healthcare, retail, and banking, it becomes evident that the food and beverage industry has significantly less AI investment from venture capitalists than the healthcare and financial sectors (Figure 9). This discrepancy suggests that AI technologies are relatively less prevalent in the food and beverage industry. In 2019, investments in healthcare, pharmaceuticals, biotechnology, and financial and insurance services were relatively on par.

Figure 9. VC investments in USD millions in AI by industry



Note: Due to insufficient data, the health sector represents health care, pharmaceuticals, and biotechnology, while financial and insurance services represent banking. In addition, the retail and consumer goods industries are analysed together as the food and beverage industry.

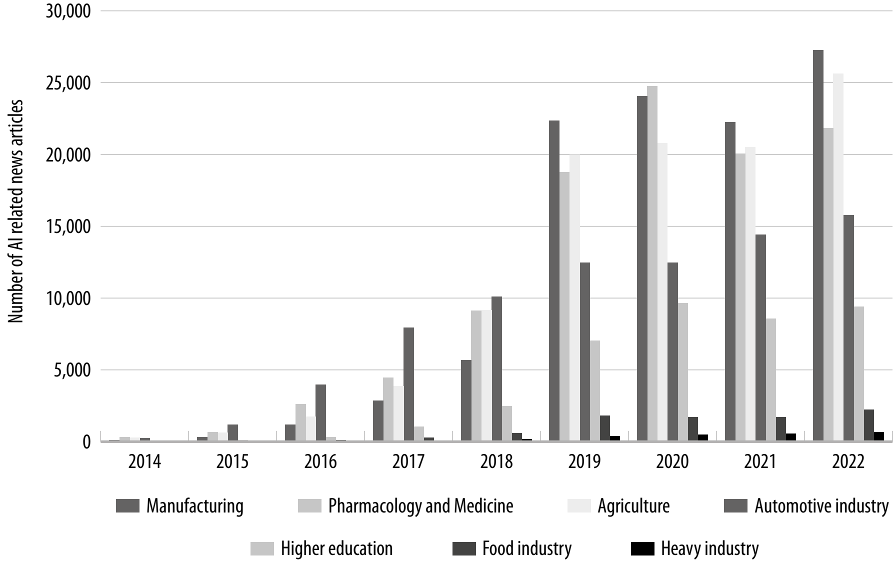
Source: OECD.AI (2023a).

However, a key shift occurred in 2020, when both sectors saw significant increases in AI investment. Healthcare, in particular, surpassed financial and insurance services in terms of growth during this period. This upward trend continued through 2021 when both sectors reached their highest levels of investment. These trends highlight potential discrepancies in the adoption of AI technologies between the food and beverage industry and the healthcare and financial sectors, indicating that the food and beverage industry has been less rapid in adopting AI-driven innovations, which is in line with the typical characteristics of the business environment of these sectors.

3.2 News coverage in AI

To understand the importance of AI, an in-depth examination of the number of news articles related to various industries from 2014 to 2022 was carried out (Figure 10). Unfortunately, incorporating financial services, retail, and consumer goods into the analysis was not possible due to a lack of data. The comparison of various industries reveals the central role of AI in sectors such as pharmacology and medicine (healthcare), manufacturing, and agriculture. Moreover, the increasing trend is observable in all studied sectors within a given time frame, offering insights into its overall importance.

Figure 10. Number of AI-related news articles by industry from 2014 to 2022

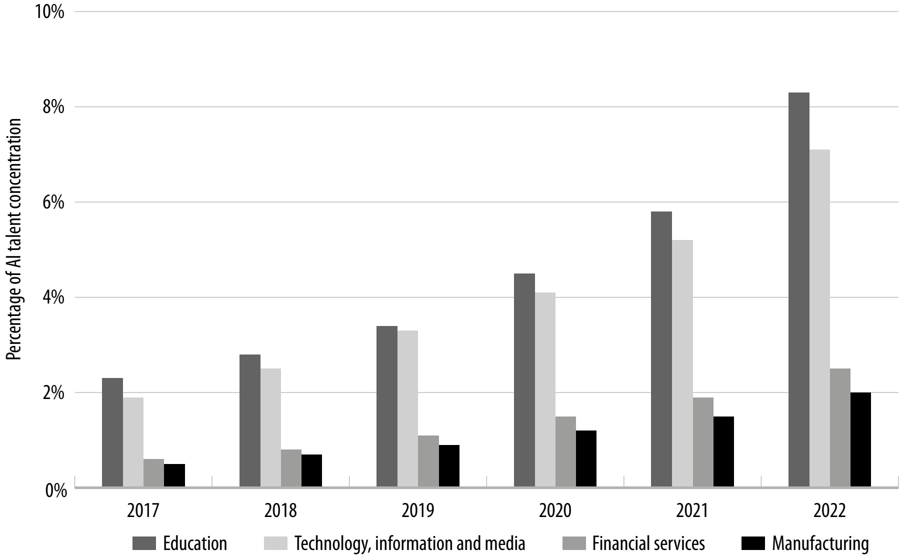


Source: IJS Data using Github (2023).

3.3 AI talent concentration by industry

The share of AI-related jobs in the financial sector was examined compared to several other industries. Due to limited available data, healthcare and retail could not be included in this study. Interestingly, a higher concentration of AI expertise in both education and technology, compared to the financial sector, was found (Figure 11). In addition, on average, the financial sector is similarly represented as the manufacturing sector. Most notably, all of these sectors have seen a steady increase in the number of AI-related jobs between 2014 and 2022. This upward trend could indicate the increasing importance of and demand for AI skills in the labour market and set the stage for further developments in the coming years.

Figure 11. Percentage of AI talent concentration by industry from 2014 to 2022



Note: The data reflects the concentration of AI talent, which measures the percentage of LinkedIn members with AI skills or in AI-related occupations such as machine learning engineering. This percentage is a relative average that is not tied to population size and includes specific countries: Germany (Europe), the United Kingdom (Europe), India (Asia), Japan (Asia), Australia (Oceania), Brazil (South America), and the United States (North America). Each country represents a specific continental region of the world, and certain countries, such as China, were excluded from the study due to insufficient data.

Source: OECD.AI (2023b).

Conclusion

Over the past decade, AI adoption has varied by region. North America, especially the United States, has consistently led the way in AI research and innovation with numerous AI projects, patents, and news articles. Europe has made progress in AI patents and increased government funding, while Oceania, although engaged in AI research, has received less global attention. Asia's AI landscape is diverse, with differences in the quality of research and AI-related media messaging across countries. South America lags far behind in most areas. However, in recent years, in contrast to other indicators, it has overtaken Asia in AI-related software projects.

Comparing these regions, North America leads in AI research and investment, followed closely by Europe in research and AI-related news. Oceania's contributions are significant but often overlooked. The observation that Asia lags behind North America and Oceania in research quality, as reflected in lower citation rates, reflects this diversity within the continent, with some countries excelling while others lag behind. South America lags far behind but is beginning to make progress in AI adoption. The United States leads the way in funding AI VC, followed closely by China. European government involvement is significant but lags in combined VC and government funding. AI-related job postings show a steady increase, highlighting the growing importance of AI and employment opportunities worldwide.

AI implementation varies by industry. In healthcare, AI promises improved diagnostic efficiency, personalised treatments, and smart implants, although it faces privacy and regulatory challenges. In banking, particularly generative AI is improving productivity, decision-making, and customer service through applications such as chatbots and facial recognition. The retail and consumer goods industries are benefiting from AI by streamlining customer service, marketing, and inventory management, with generative AI personalising offers and improving content creation. VC investments show significant growth in healthcare and finance, while AI talent is more concentrated in education and technology, reflecting rising demand across all sectors.

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ADOPTION OF AI TECHNOLOGIES IN SLOVENIA

Introduction

Similar to many Western countries, Slovenia has gradually introduced AI technologies in various industries and has been heavily involved in AI research and innovation (e.g., it ranks second only to Switzerland in research per capita in this analysis). However, moving away from the per capita numbers, the lag becomes more evident. Academic institutions and research centres have played an important role in driving AI projects and contributing to advances in the field. The Slovenian government has also recognised the importance of AI and digital technologies. It funds the second most projects per million inhabitants among the ten European countries surveyed, focusing on initiatives to promote digital transformation and innovation, with AI playing a crucial role (IJS data, 2023).

Various industries in Slovenia have begun incorporating AI technologies into their daily operations. Slovenia has also seen the emergence of AI-focused start-ups (e.g., Abelium, Outbrain, Revello and Sensum) working to develop AI-powered solutions for local and global markets. Partnerships with international organisations and institutions have also played a role in promoting AI technologies in Slovenia, particularly the OECD and "Jožef Stefan" Institute (IJS) collaborations (OECD, 2023a).

The chapter will mainly revolve around Slovenia's relative position in the adoption of artificial intelligence compared to selected European countries over time and the issue of Slovenia developing or lagging behind other developed countries. Furthermore, the chapter will discuss the differences at the industry level and who are the winners in the integration of AI technologies.

1 Methodology

The comparative analysis of Slovenia's position in terms of AI is based on the IJS dataset (IJS Data, 2023). The lab collects the data from various data sources (OECD, 2023c). Slovenia was compared to two relevant groups of European countries (Table 1). To better understand the relative position among countries, a comparison was performed of Slovenia (SVN) with the Alpine Bloc (AB), i.e. countries considered to be more technologically advanced and industrial leaders in Europe, and with the Visegrad Group (VGG), which has a similar GDP and industrial composition (a mix of manufacturing and services).

Table 1. Division of the selected European countries into country groups

Group	Countries
The Alpine Bloc (AB)	Germany (DEU), Switzerland (CHE), Italy (ITA), Austria (AUT) and France (FRA)
The Visegrad Group (VGG)	Czech Republic (CZE), Poland (POL), Hungary (HUN) and Slovakia (SVK)

Source: Own work (2023).

Following the stages of tracking AI innovations (Grobelnik, 2021), Slovenia is compared to other countries (Table 1) based on the following indicators: AI-related research, number of AI projects, funding of projects, and AI-related news articles. In addition, the focus was put on comparing different industries based on data retrieved from the OECD. Comparison among various industries – education, finance, manufacturing, professional services, technology, information, and media – was carried out based on the percentage of employees indicating AI-related roles as their occupation on their LinkedIn profiles. Approximations of what these percentages mean in absolute terms were calculated by multiplying them by the number of employees in the industry in Slovenia in 2021. Furthermore, an examination of VC investments in AI projects in different sectors within Slovenia was conducted, relying on data from the OECD dataset.

2 Adoption of AI technologies in Slovenia

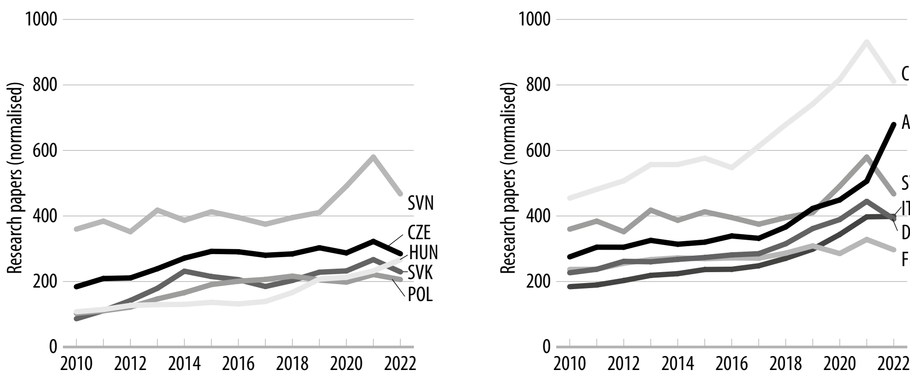
The following section presents the status of AI technology in Slovenia using data from IJS. This analysis spans from 2010 to 2022 and compares Slovenia with other relevant European countries for context. Slovenia is frequently compared to these countries due to its self-management history, transition to a market economy in the 1990s, central European location, and EU membership since 2004. To track AI innovation phases, close attention should be paid to the indicators (Marinšek et al., 2023).

2.1 AI-related research in Slovenia

Research is closely related to the number of AI research papers published on a given topic and their citations. The study focused on AI-related research papers and their citations, which were normalised to account for the so-called “citation lag” or “time-dependent bias”. The number of citations depends on how long an article has been cited. More recent research has less time to accumulate citations than older research.

To analyse the number of research papers published per capita, Slovenia is compared to AB countries on the left and VGG on the right (Figure 1). The year 2022 was excluded from the analysis because it shows an unexplained decrease in research papers for all countries, probably due to insufficient time to collect data for 2022. Compared to the Visegrad countries, Slovenia leads by far with 579.69 AI-related research papers per million population, while Slovakia is second with 266.76 papers in 2021. Compared to AB, Slovenia ranks second on this indicator, behind Switzerland, which has 931.17 AI-related research papers per million inhabitants. Slovenia is clearly among the most developed countries in the field of AI research, even compared to AB.

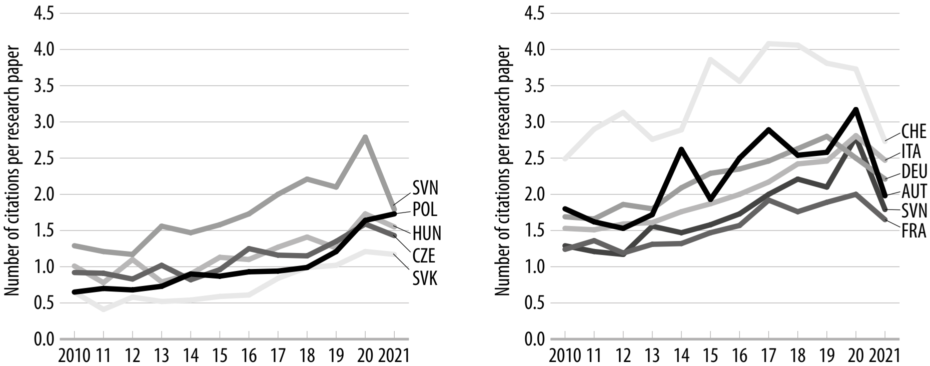
Figure 1. Number of AI-related scientific papers per million inhabitants by country from 2010 to 2021



Source: IJS Data using Mag/OpenAlex (2023).

The number of citations per scientific paper per year indicates the quality of research in a given country, as the number of research papers could provide misleading information about the importance and impact of research papers. Papers from Austria, Switzerland, Italy, and Germany were more cited compared to Slovenian research papers (Figure 2), especially in recent years. Switzerland is again far ahead of other countries, while Slovenia closed the gap to other AB countries. Slovenia is the leader compared to VGG (Figure 2).

Figure 2. Number of annual citations per research paper by country from 2010 to 2021



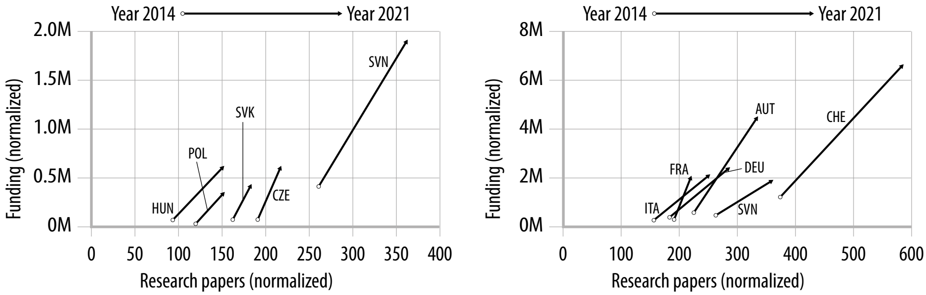
Source: IJS Data using Mag/OpenAlex (2023).

2.2 AI-related funding and projects

Comparing the number of research papers and grants (Figure 3), the pattern of growth in grants and projects per million population from 2014 to 2021 is evident. The overall winner in the studied sample of the AI competition seems to be Switzerland. Compared to AB, Slovenia ranks third behind Switzerland and Austria but has improved by far the most when considered in the VGG context. There is a strong correlation between the published research papers and the funding of the projects in the respective years (Figure 3).

Switzerland is far ahead in the number of research papers and projects (Figures 4 and 5). Slovenia made the most progress in terms of the absolute values of the indicators and has the best overall position compared to the VGG. An increase in all indicators is shown in 2021 compared to 2014 for all countries, which makes sense given the research and adoption of AI in recent years.

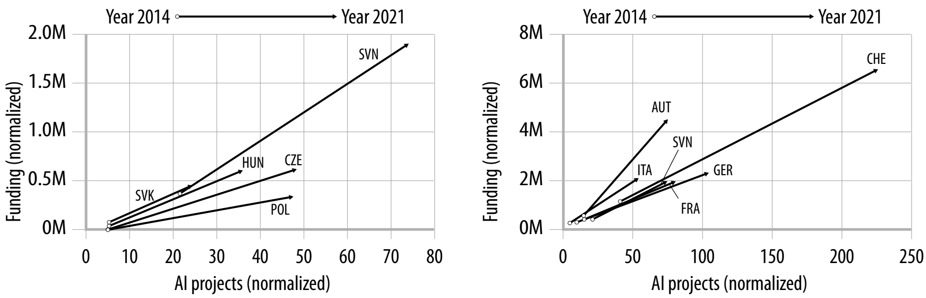
Figure 3. Comparison of research papers and funding per million inhabitants by country in 2014 and 2021



Note: Different scales on the two charts. Data is normalised per million inhabitants.

Source: IJS Data using Mag/OpenAlex and Crodis (2023).

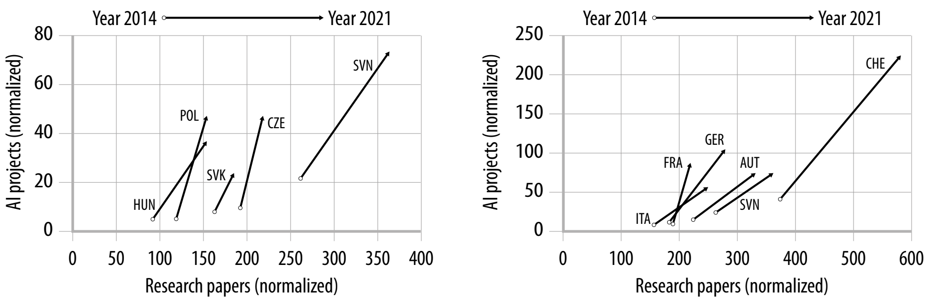
Figure 4. Comparison of research papers and AI projects per million inhabitants by country in 2014 and 2021



Note: Different scales on the two charts. Data is normalised per million inhabitants.

Source: IJS Data using Github and Codris (2023).

Figure 5. Comparison of AI projects and funding per million inhabitants by country in 2014 and 2021

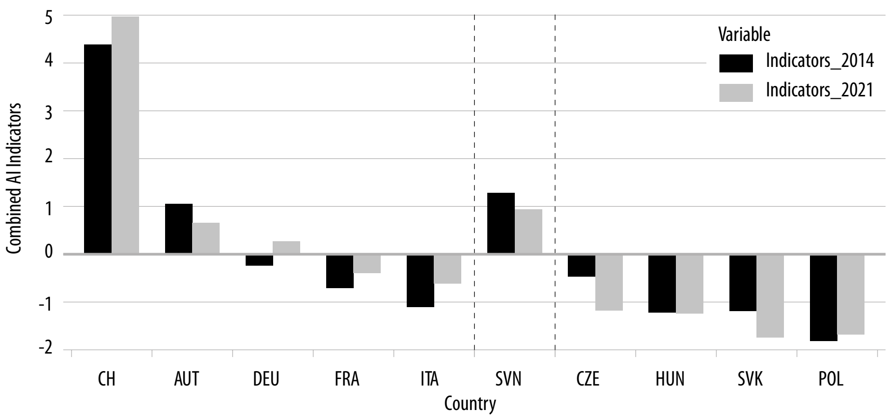


Note: Different scales on the two charts. Data is normalised per million inhabitants.

Source: IJS Data using Mag/OpenAlex and Github (2023).

As AI-related research papers and government support increase in Slovenia, more and more AI projects are being funded. The funding per million euros in Slovenia increased by 41.69 percent per year from 2010 to 2021, again second only to Switzerland, which saw an average annual increase of 55.12 percent. The patterns of growth are quite similar across all indicators, with Switzerland being the one that has improved most and countries of VGG being those that have improved much less compared to countries of AB.

Figure 6. Position of countries by combined AI indicators, 2014 vs. 2021



Note: The combined AI indicators were obtained by principal component analysis using the standardised values of all four indicators used in this chapter. Higher values represent a better relative position of a country.

Source: IJS Data (2023).

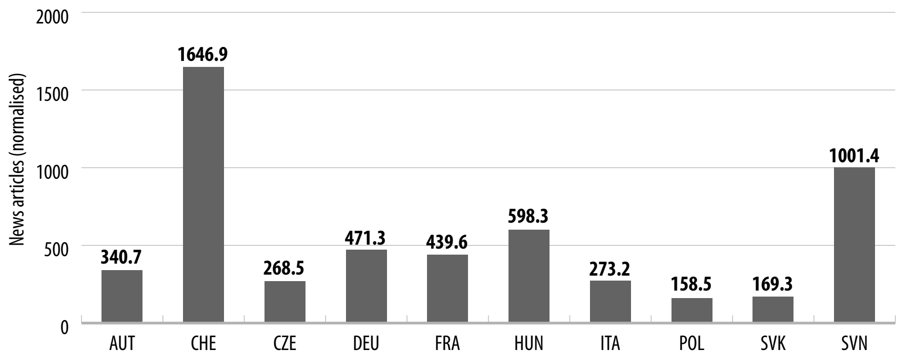
To better understand the position of the countries in relation to each other, principal component analysis (PCA) was performed using all four indicators (Figure 6). Switzerland is clearly in the lead and has even increased its lead compared to the other countries. Slovenia was second in data per million inhabitants, and Austria was third in both 2014 and 2021, but the position of both countries worsened over the seven years observed. Poland had the worst position among the observed countries in 2014, but its improvement and Slovakia's decline in AI-related indicators caused the latter country to take Poland's place. Again, it is worth noting that Slovenia is far ahead of VGG and is the only country above average in the observed group. Looking at Germany, it is visible that it has moved from below-average performance on indicators per million inhabitants in 2014 to above-average results in 2021 (Marr, 2021).

As the PCA analysis reveals only the relative position of the country compared to others considering all four indicators, the goal was to try and see what each individual country has an edge on compared to others. The patterns of growth are quite similar across all indicators, with Switzerland being the one that has improved most and countries of VGG being those that have improved much less compared to countries of AB.

2.3 AI-related news

In terms of AI-related news, Slovenia is again behind only Switzerland, which has 1446 news per million inhabitants in 2021, while Slovenia has 1061 news in the same year. Other countries are far behind: Hungary (553), Germany (444), and France (396) (Figure 7).

Figure 7. Comparison of AI-related news articles per million inhabitants by country in 2021



Note: Data is normalised per million inhabitants.

Source: IJS Data (2023).

3 Comparison of industries

3.1 AI jobs in industries

The largest share of AI jobs in Slovenia or those who perform an AI occupation (e.g. machine learning engineer) is in education (Figure 8). The education sector showed the most significant growth in recent years, from 2.6 percent in 2019 to 7 percent in 2022. The sector with the second most AI-related jobs in Slovenia is technology, information, and media, but with a much lower percentage, growing from 1.8 percent in 2019 to 2.8 percent in 2022. The smallest percentage of AI jobs in Slovenia are in the manufacturing sector (less than 1 percent in 2022) and the financial sector (about 1 percent in 2022). Again, this underscores the finding that Slovenia is stronger in research than business practice.

Percentages were transformed to actual employees based on Slovenian government data (RS MJU, 2023). LinkedIn percentage job data (OECD, 2023b) was used as a sample and applied to the population (RS MJU, 2023). The numbers are presented in Table 2.

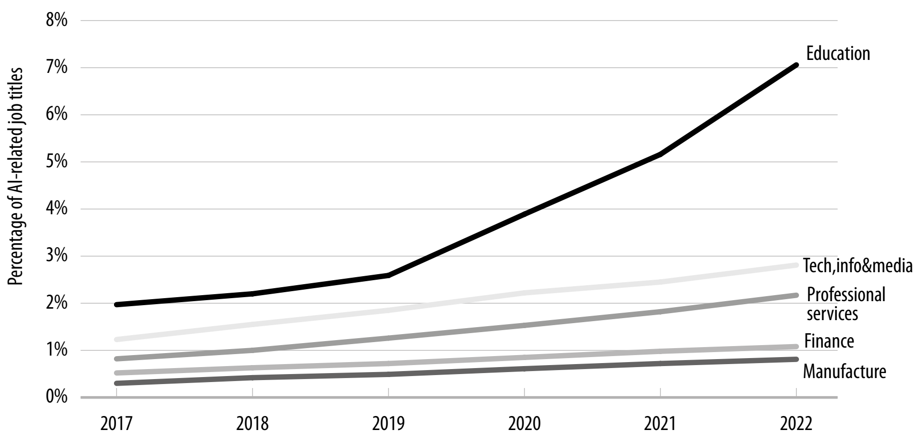
Table 2. Number of people working AI-related jobs in Slovenia by industry

	2017	2018	2019	2020	2021	2022
Education	1,477	1,650	1,942	2,917	3,870	5,295
Tech, info & media	360	454	542	650	718	823
Professional services	479	584	735	893	1,062	1,266
Manufacturing	606	848	990	1,232	1,454	1,636
Finance	103	125	143	169	195	214

Note: The data is based on the sample of LinkedIn job description percentages, and these figures are then applied to the population of Slovenian employees by industry. This sample might not be truly representative of the population, as people who work with new technologies like AI are also more likely to have LinkedIn profiles. Thus, this data likely includes a base neglect bias and is an overestimation of the actual numbers.

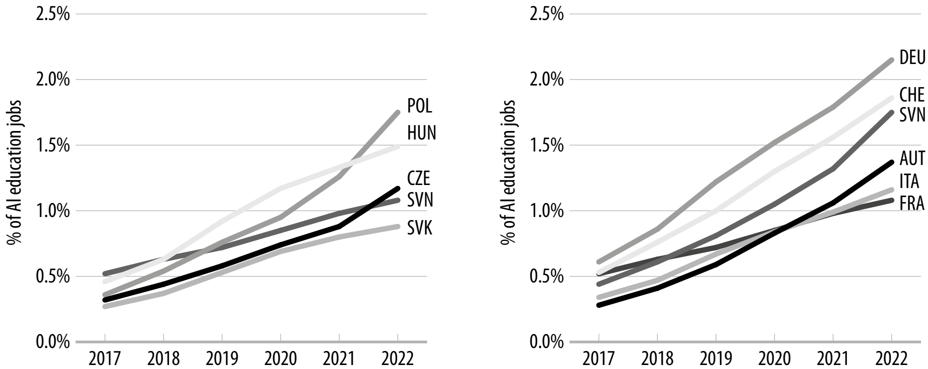
Source: OECD (2023b), RS MJU (2023).

Figure 8. Percentage of AI-related job titles on LinkedIn in Slovenia by industry from 2017 to 2022



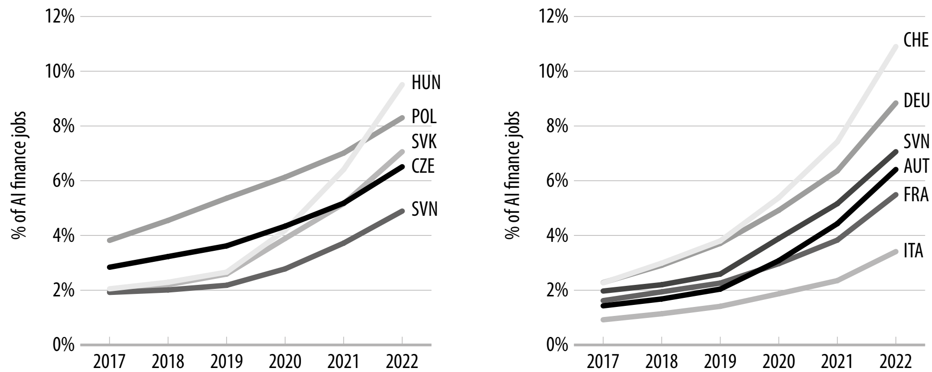
Source: OECD (2023b).

Figure 9. Percentage of AI-related job titles on LinkedIn in the education industry by country from 2017 to 20221



Source: OECD (2023b).

Figure 10. Percentage of AI-related job titles on LinkedIn in the finance industry by country from 2017 to 2022



Source: OECD (2023b).

The figures show the strengths of Slovenian research (Figure 9) and the lag in its business implementation (Figure 10). When comparing the education sector with the two groups AB and VGG, Slovenia ranks third. However, when comparing the financial industry, Slovenia ranks almost last, surpassing only Slovakia in the number of AI-related jobs in the financial sector.

3.2 Venture Capital (VC) investments into different Slovenian industries

Looking at VC investments in Slovenian AI companies, positive trends are visible. The business processes and support services industry received 1.7 million USD in VC AI investments in 2019; this figure more than doubled in 2020 to 4.4 million USD dollars and reached 9.7 million in 2022. The media, social platforms, and marketing industry show a similar trend, starting at 0.23 million USD in 2019 and receiving 6 million in 2022. Both industries had no investments in 2021, possibly due to the global pandemic. Healthcare, drugs, and biotechnology received 12 million USD in 2018 and are predicted to receive around 20 million USD in 2023, showing a positive trend as well (OECD, 2023b).

3.3 Slovenian AI patents by industry

Slovenian AI patents were rare from 2010 to 2022, with only five patents, or 2.4 per million population, all in the medical industry. Germany had 6,000 patents, or 73.4 per million population, in the same years from 2010 to 2021 (most of them in the medical field, with 87 percent of all patents filed). Slovenia's southern and eastern neighbours fared worse (Hungary with 0.2 patents per million inhabitants and Croatia with 0), while its northern and western neighbours fared much better. Italy filed 20 AI patents per million inhabitants, again mainly in the medical field, which accounted for 93 percent of patents across all industries. Austria filed 7.6 AI patents per million inhabitants, 70 percent of which were in medicine and 26 percent in robotics.

Conclusion

The research has shown informative findings; however, it should be considered with caution. The data for comparison of Slovenia to other countries was hard to obtain and needed further modification, such as standardisation and population estimates. The size of the countries could influence the data significantly when presenting data per million inhabitants and consequently present a more favourable position for smaller countries. Furthermore, in some instances of AI-related jobs, the sample could prove to be unrepresentative of the population.

Although Slovenia is often compared to countries classified as VGG (Czech Republic, Poland, Hungary, and Slovakia), the conclusion is that these countries have performed worse than Slovenia in recent years on all observed indicators (research, funding, projects, etc.). The relative position of Slovenia compared to AB countries (Germany, Switzerland, Italy, Austria and France) is still very good. The only country that performs better than Slovenia on all observed per capita indicators is Switzerland, which is far ahead of all other countries included in the analysis. The combined AI indicator shows that Slovenia is currently in second place, but its position has deteriorated compared to its position in 2014, which may indicate a possible future lag in AI-related development compared to countries of AB in the upcoming years. Slovenia is particularly successful in producing a large number of research papers per million inhabitants. It has managed to maintain its second place from 2014 to 2021, but its competitors are improving faster than Slovenia (Figure 3).

Slovenia is ahead of most European countries in the areas of AI research papers, news, and citations per capita. This result is mainly due to IJS, which, according to Forbes, is 'the best AI research institution in the world' (SPIRIT Slovenia, 2022). However, it seems to lag behind other AB countries in funding and projects, which means that it is not as effective in translating the research results of its scientists into industry, or it might be that the research funding is ineffective. The funds raised by the companies in Slovenia are mostly used to finance research and increase researchers' wages. These funds fuel the prominent research per million inhabitants in Slovenia; however, there is little ambition to implement the findings. Most researchers even set up companies to acquire funds from the European Union and not patent or monetise their research, consequently not significantly contributing to the Slovenian economy. Another limitation of EU grants is that they are commonly quite narrow in use, and the findings are often not feasible and viable to implement in the economy (Koman et al., 2023).

When looking at the differences on the industry level, the statement is substantiated, and education is clearly visible as the winner in integrating AI technologies. In the financial industry, Slovenia ranks last compared to Germany, Switzerland, Italy, Austria, and France and fourth (out of five) compared to the Czech Republic, Poland, Hungary, and Slovakia, having only a higher percentage of AI LinkedIn jobs than Slovakia. Looking at the investments of VCs in Slovenian companies, a positive trend can be seen in investment inflows from VCs; however, patents are still uncommon in Slovenia. Nevertheless, Slovenia seems to have experts who are well-versed in artificial intelligence, which could prove to be a strong basis for further expanding AI technology.

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THE ROLE OF REGULATORS

Introduction

Regulation of artificial intelligence (AI) is pivotal in shaping the responsible evolution of AI technologies, encompassing comprehensive rules, standards, and guidelines that govern every facet of AI development and deployment. While AI integration can boost productivity, it can also be responsible for an exponential increase in mis/disinformation campaigns leading to public opinion manipulation (Repede, 2023), resulting in anti-competitive markets (Kovač, 2022; Krausova 2019), and market dominance abuse (Krausova, 2019). Striking a harmonious balance between innovation and regulation is paramount to cultivating a trusted and responsible AI ecosystem aligned with shared values, especially given the transformative power of AI.

The chapter focuses on conceptual tools and obstacles to regulating AI, the current state of AI regulations and the key differences between global powers. Then, the focus is on the risks of regulating AI in terms of competition regulation, consumer law, and intellectual property. A comparative analysis of regulatory approaches towards AI within the European Union (EU), the United States (USA), and China unveiled nuanced distinctions and similarities while exploring their economic implications. A diverse array of academic literature was analysed to provide a comprehensive perspective on this multifaceted subject.

The chapter is structured into three parts. First, the AI's impact on economic growth is presented, followed by a comparative analysis between China, the EU, and the USA. Competition, consumer welfare, and intellectual property regulation are in focus in the last part of the chapter.

1 Defining the imperative for AI regulation

The ascent of AI has indeed ushered in innovation, but it has simultaneously surfaced complex regulatory challenges. **Ethical concerns** emerge due to AI's autonomous decision-making, perpetuating bias and inequality (Bostrom & Yudkowsky, 2014; Mittelstadt et al., 2016). **Privacy** becomes a central issue, as AI's data analysis capabilities raise concerns, necessitating robust consent mechanisms and oversight (Solove, 2006; Floridi, 2014). Furthermore, **economic disparities** may deepen with AI's integration into the workforce, prompting the need for proactive measures (Bessen & Brynjolfsson, 2019; Chui et al., 2016). **Security** is a growing concern, as AI systems remain vulnerable to malicious exploitation, demanding rigorous regulatory standards (Goodfellow et al., 2016; Schneier, 2018). Lastly, establishing clear **legal frameworks** is vital for determining responsibility in cases of AI malfunction or harm and addressing accountability gaps (Hutter et al., 2018; Diakopoulos, 2016). These challenges underscore the complex landscape of AI regulation.

Kovac (2022) and Russell and Norvig (2016) draw attention to liability risks inherent in AI, which encompass autonomy (about individual AI decisions), association (concerning cooperation between humans and AI agents), and network risks (involving integration with other computer systems). If left unaddressed, these liability risks can introduce uncertainties and potentially curtail AI development, thereby affecting economic growth. Additionally, in addressing these challenges, Table 1 outlines the practical applications of AI in specific areas, highlighting how AI can affect competition, consumers, transparency, and ethics. For each area, it provides insights into how AI achieves these outcomes and the role of legislation in addressing associated challenges. The table emphasises the need for regulatory frameworks to mitigate risks and promote responsible AI development across various domains. Regulatory responses to these challenges can vary, ranging from stringent prohibitions to industry-led self-regulation. Furthermore, the effectiveness of AI regulation hinges on transparency (Chan et al., 2022). Without understanding AI's inner workings, regulators may struggle to craft efficient, growth-friendly policies.

These challenges underscore the urgency of effective AI regulation. The task at hand is to strike an intricate balance in fostering innovation while safeguarding individuals, businesses, and the broader society, which calls for unified international AI regulation (Wu & Liu, 2023) and collaborative efforts among regulatory authorities, industry stakeholders, and AI innovators.

Table 1. AI impact areas and legislative responses

AI	How this is possible	The role of legislation
Limiting competition - Price optimisation algorithms	AI can enable dynamic pricing strategies that limit competition by automatically adjusting prices based on various factors, potentially leading to collusion or price-fixing.	Legislation should detect and penalise anti-competitive pricing strategies.
Consumer exploitation - Personalised content recommendation	AI can exploit consumers by tailoring content or advertisements to manipulate preferences, potentially leading to excessive spending and exploitation.	Legislation mandates data usage transparency and limits on data collection.
The lack of transparency - Complex deep learning algorithms	AI's complexity can lead to a lack of transparency, making it difficult to understand and interpret its decision-making processes.	Legislation requires explainability and transparency standards.
Ethics - Bias in AI algorithms	AI can perpetuate bias and discrimination if not properly designed and monitored.	Legislation mandates ethical design principles, diversity in training data, and accountability frameworks.

Source: FTC Report (2021), GDPR (2018), CCPA (2018), EU AI Act (2021), Algorithmic Accountability Act (2022).

2 Comparative assessment of regulatory approaches towards AI in the EU, US and China

2.1 EU: A command-and-control for risk-based classification

In 2021, the EU enacted the Artificial Intelligence Act (EU AI Act), a comprehensive regulatory framework to ensure trustworthy AI. This approach prioritises consumer protection by imposing stringent requirements on AI systems (EU AI Act, 2021). The EU AI Act categorises AI systems based on risk, with high-risk systems subject to strict regulations, including transparency and interpretability standards, ensuring accountability and accessibility (EU AI Act, 2021).

To facilitate the market entry of AI technology, the EU has introduced a 'CE (Conformité Européenne) - marking procedure', which provides specific standards for different AI applications and increases adaptability (Akinola et al., 2022). The EU also addresses AI systems posing unacceptable risks to individuals or vulnerable groups, subjecting them to rigorous testing before public availability, promoting safety and compliance (Chan et al., 2022). Additionally, the EU has enacted the General Data Protection Regulation (GDPR) and the Digital Services Act (DSA) to further regulate AI, ensuring comprehensive oversight and safeguarding user rights. Testing and Experimentation Facilities

(TEFs) further support AI technology providers, facilitating practical validation across various sectors (Chan et al., 2022).

The EU maintains its leadership in AI regulation, focusing on a balanced framework that addresses liability issues, particularly for high-risk AI applications like ChatGPT and GPT-4, and harmonises regulations across member states (Hacker, 2022). To promote innovation and support for SME developers and promote trustworthy AI, the EU is taking sustainability into account by integrating sustainability assessments into their regulatory processes. These assessments consider the environmental, social, and economic impacts of AI systems, especially models like GPT. However, while promoting algorithmic accountability, the EU's approach may unintentionally increase entry barriers and compliance costs, potentially stifling AI innovation (Chan et al., 2022).

The future of AI in Europe holds significant promise and potential, marked by both opportunities and challenges. As AI continues to develop in various sectors, businesses should anticipate a more stringent regulatory environment focused on ensuring ethical AI development and deployment (EU AI Act, 2021). It is crucial for companies to proactively engage with evolving regulations and invest in robust compliance measures. This step may involve building AI systems with built-in transparency and accountability features and conducting thorough impact assessments to address sustainability concerns. Transparent AI models that provide clear decision explanations need to be implemented. For instance, in healthcare, an AI diagnosing diseases could explain its diagnoses. Conducting thorough impact assessments means evaluating how AI systems may affect the environment, society, and the economy. For example, before deploying an AI-driven transportation system, a comprehensive assessment considers its environmental, social, and economic impacts (EU AI Act, 2021). Moreover, as Europe continues to emphasise consumer protection and privacy, businesses should prioritise data security and user rights in their AI applications (Chan et al., 2022). The future of AI in Europe is one where responsible and trustworthy AI technologies will be pivotal for business success and ensuring alignment with the continent's evolving regulatory landscape.

2.2 USA: A targeted, decentralised approach to AI regulation

The United States has adopted a case-specific, decentralised, and agency-specific approach to AI regulation, contrasting with the EU's more centralised command-based approach. While emphasising fairness, transparency, and accountability, this approach aims to stimulate innovation and strengthen consumer rights nationwide (Akinola et al., 2022). The advantages of the US approach are mostly the **flexibility and responsiveness**. By proposing guidelines on an agency-specific basis, the U.S. regulatory framework can adapt quickly to the evolving AI landscape, addressing specific issues as they arise. This decentralised approach enables regulatory agencies to focus on the unique challenges posed by different AI applications. Another advantage of this approach is **lower transaction costs**. The agency-specific approach reduces the bureaucratic burden on businesses, which can lower compliance costs and foster innovation within the AI sector.

The U.S. Department of Commerce introduced a risk management framework, while the Food and Drug Administration (FDA) initiated the AI-based software as a Medical Device Action Plan. To safeguard privacy and civil liberties, the National Security Commission on Artificial Intelligence strongly emphasised these concerns in its final report in 2021. Furthermore, the Algorithmic Accountability Act of 2022 now mandates that companies assess the fairness and transparency of automated decision-making processes (NSCAI, 2021; AAA Proposal, 2022). However, this approach may also have potential drawbacks, such as fragmentation and inconsistencies in regulations between agencies (Mökander et al., 2022). Additionally, it places a significant responsibility on individual agencies to interpret and enforce AI regulations effectively.

2.3 China: A blend of ethics and control

China has adopted a multifaceted approach to AI regulation nationally. It adopted the New Generation Artificial Intelligence Development Plan (AIDP) 2017 and the Cybersecurity Law in 2017, prioritising data protection and privacy (Roberts et al., 2020). The AIDP underscores the country's ambition to become a global technology leader (AIDP, 2017) and emphasises defence and public order concerns (Roberts et al., 2020).

Their approach to AI regulation combines ethical considerations with control measures (Chan et al., 2022). To enhance transparency and combat illegal information via algorithmic recommendation services, China also implemented the 'Internet Information Service Algorithmic Recommendation Management Provisions' (Chan et al., 2022). This approach reflects the country's dual objectives of mitigating malicious practices, such as spreading harmful content and cultivating domestic innovation. By fostering a supportive ecosystem, they are creating a robust domestic market for AI products and services, providing various forms of governmental support like grants and tax incentives, and ensuring a business-friendly environment through streamlined processes and intellectual property protection. These measures collectively empower local AI firms, enabling them to thrive, seize market opportunities, and contribute to economic growth and technological advancement within the AI sector (Chan et al., 2022).

In 2021, the China Academy of Information and Communications Technology issued a 'Trustworthy AI' white paper, proposing the adoption of techniques like federative learning and differential privacy to bolster the resilience of AI systems against cyber threats (Wu, 2022). Subsequently, the Ministry of Science and Technology released Ethical Norms for New Generation Artificial Intelligence in September 2021, covering critical aspects such as personal information usage and protection, human oversight of AI, and preventing AI-related monopolies (Wu, 2022).

Table 2 allows the analysis of these different legislative steps. It shows which legal actors are concerned about the different issues.

Table 2. Comparison of main characteristics of AI legislation in the EU, USA and China

Region	Main AI acts / regulation	Main characteristics	What field it addresses
EU	AI Act, GDPR (Data Protection), and Digital Services Act (DSA).	AI Act seeks to regulate AI systems' use, AI governance, and conformity assessments. GDPR and DSA address data protection and digital services intersecting with AI.	Governance, Data Protection, Digital Services.
USA	AAA, AI in Government Act of 2019, AI Regulatory Modernization Act, AI Transparency Act, Data Protection and Privacy Legislation.	Establishing AI regulatory frameworks, ensuring transparency, and addressing AI ethics and safety concerns.	Government, Regulation, Transparency, Ethics, Safety.
China	China's AI New Generation Development Plan, Cybersecurity Law, and AI Security White Paper.	China's AI initiatives aim to foster AI development, enhance cybersecurity, and establish standards for AI security.	Development, Cybersecurity, Security Standards.

Source: Akinola et al. (2022), AAA Proposal (2022), EU AI Act, (2021); DSA, DMA, Chan et al., (2022), Roberts et al. (2020).

2.4 Comparative analysis: Economic implications

The EU prioritises consumer protection through regulations like the EU AI Act, Digital Services Act (DSA), and Digital Market Act (DMA) (EU AI Act, 2021). However, these rules, particularly for high-risk AI systems, can increase compliance costs, including technical adaptations, legal and consulting fees, testing, and operational changes, potentially hampering innovation.

For instance, healthcare-related AI start-ups may face significant compliance expenses under the EU AI Act, potentially hindering their ability to innovate. In contrast, the EU's centralised approach for uniform regulation across member states, focusing on categorising AI systems by risk and imposing stringent standards, may struggle to keep pace with rapidly evolving AI technologies and adapt to specific use cases, leading to higher compliance costs and potential innovation impediments (Chan et al., 2022).

In contrast, the USA emphasises innovation with a flexible regulatory approach through the AAA proposal (Akinola et al., 2022). The success of this approach hinges on the implementation and adaptability of the proposed regulations, which will play a pivotal role in driving innovation within the country's AI landscape (Mökander et al., 2022). Factors like flexible employment legislation and competitive workers' remuneration have contributed to the flourishing AI innovation ecosystem in the USA (Orrick, Herrington & Sutcliffe LLP et al., 2021).

Unlike the EU and the United States, China pursues a unique strategy, blending ethics with regulatory control to encourage domestic AI innovation while safeguarding consumers and establishing itself as a global AI leader (Chan et al., 2022). This approach aims to create a robust AI ecosystem that fosters innovation while maintaining strict oversight for consumer protection and ethical AI practices.

EU prioritises consumer protection, slowing innovation (EU AI Act, 2021; DSA, DMA; Chan et al., 2022); the USA seeks a balance between innovation and regulation (Akinola et al., 2022; Mökander et al., 2022; Orrick, Herrington & Sutcliffe LLP et al., 2021), and China promotes innovation with strong domestic safeguards (Chan et al., 2022). Table 3 gives an idea of these different legal approaches.

Table 3. Economic implications of AI regulations in the EU, USA and China

Region	Regulatory approach	Economic implications
EU	Command-and-control consumer-focused regulations and AI-specific acts.	May slow AI innovation and increase compliance costs but prioritise consumer welfare.
USA	Focuses on innovation and economic growth with fairness and transparency.	Balances consumer protection with innovation and relies on practical implementation, fostering a thriving AI innovation ecosystem.
China	Promotes domestic innovation while safeguarding consumers.	Encourages AI innovation, strikes a balance between control and innovation, and focuses on nurturing the domestic AI industry.

Source: EU AI Act (2021), DSA, DMA; Chan et al. (2022), Akinola et al. (2022), Orrick, Herrington& Sutcliffe LLP et al. (2021).

3 EU AI Act's regulatory effects on competition

3.1 Big data, AIs and competition regulation

The emergence of Big Data and AI has created significant advantages for data holders since the combination reinforces dominance in other markets or enables dominant entities to accumulate and exploit data effectively. This approach diminishes a competitive market, especially since it can provide a covert dominant market position without a dominant market share (Hayashi and Arai, 2019) and can infringe upon Article 102 of the Treaty on the Functioning of the European Union TEFU (Official Journal C 326, 26/10/2012 P. 0001 - 0390), while data also serves as a barrier to entry, making it essential for business competitiveness (Scheuerer, 2021).

However, assessing anti-competitiveness requires a lengthy case-by-case examination, creating a need for a more standardised approach that regulators will aim to fill by introducing standards and regulations, connecting big data and AI dominance with market dominance (Barsotti and Kocer, 2022). Businesses should anticipate more stringent regulatory standards of full transparency, dataset acquisition, dataset usage, and the nature and size of the datasets themselves (Scheuere, 2021).

Table 4. Compliance and verification costs between providers, deployers, SMEs and enterprises, in EUR

Compliance costs (low- to mid-risk systems level)	Providers	Deployers
Compliance costs	6,000–7,000	6,000–7,000
	Enterprise	SME
Verification costs	3,000–7,500	3,000–7,500
Verification costs based on third-party assessment (providers) (high-risk systems only)	Enterprise	SME
One-off audit cost of one AI system	3,000–7,500	3,000–7,500
One-time setup of a new QMS in the first year & bring one system to market	93,000–330,050	144,350–247,150
One-time adaptation of an existing QMS in the first year & bring one system to market	117,750–174,800	88,050–130,850
Annual QMS oversight and audit	71,400	71,400

Note: Compliance costs, excluding all other possible costs.

Source: Haataja & Bryson (2022).

Contrary to its aim of creating a level playing field, the EU AI Act results in compliance costs, which are less detrimental to larger enterprises than to small and medium ones (Table 4) as per the EU AI Act. The values provided in Table 4 pertain to average compliance costs imposed by the EU AI Act, estimated by the European Commission's Impact Assessment (2021a), excluding all other possible costs.

For reference, the development cost of an average AI system is estimated at €170,000. Compliance costs for providers are approximately €6,000–€7,000, representing roughly 4–5 percent of the total cost. Deployers of high-risk systems would incur annual human oversight costs of €5,000–€8,000 per deployment throughout the lifetime of the product's usage. Providers requiring third-party verification would face an extra cost of €3,000–€7,500 per system, assuming they have an audited Quality Management System (QMS) in place. The compliance costs themself consist of training data costs, costs regarding documents and traceability, provision of information, human oversight, and robustness and accuracy (European Commission, 2021b; Haataja & Bryson, 2021).

The cost of adapting or implementing Quality Management Systems (QMS) that are required for high-risk AI systems to comply with the AIA requirements for enterprises bringing one system to the market has been estimated to be between €117,750 and €174,800. For small and medium-sized enterprises (SMEs), the cost is expected to range from €88,050 to €130,850. In cases where an organisation wants to deploy a high-risk system through a third-party assessment and lacks an existing QMS, the costs for enterprises could vary from €193,000 to €330,050, and for SMEs, it could range from €144,350 to €247,150. Additionally, organisations would incur annual QMS oversight and audit costs of approximately €71,400 per one product-to-market process (Haataja & Bryson, 2021). Based on the EU's own impact assessment (2021), a small business can expect total compliance costs of up to €400,000 per one high-risk AI product requiring a quality management system (QMS). A company with €10 million turnover would see its profits fall by 40 percent. Based on the European Commission's assessment of SME's profit margin floating around 10 percent, the 40 percent loss of profit can turn a company from a profitable business to a money-losing one.

3.2 Algorithmic collusion

The extensive knowledge harnessed about consumers, including their preferences, vulnerabilities, and misconceptions, allows for targeted pricing that could potentially exploit individuals' characteristics. Furthermore, Krausova (2019) emphasises a scenario that uses pricing algorithms that learn about the market and independently determine the means to optimise profit while doing so with autonomy and price collusion or cartel-like price-setting. This behaviour stems from AI pricing algorithms colluding in the price-setting mechanism, forcing market prices to increase in unison. It is a serious issue since articles 101 and 102 of TEFU address only human collusion/cartel agreements (Krausova, 2019). Such practices could easily fall afoul of Article 101 TFEU, thereby placing the market participants at a competitive disadvantage, restricting competition, and distorting market conditions, especially when taking into account the costly (and not equally available to businesses) datasets and AI systems needed to use the latter methods (Krausova, 2019).

Pricing algorithms combined with large data sets or big data can lead to infractions of TEFU; therefore, in the future, pricing algorithms will be introduced to higher levels of scrutiny. A change in the definition of price collusion or cartel-like agreements will likely follow, leading businesses to reconsider their pricing strategies (Barsotti and Kocer, 2022).

4 The role of regulators in regulating AI by the domain of consumer protection and intellectual property (IP)

The European Union's **risk-based approach** to categorising and regulating artificial intelligence through a framework (Table 5) indicates a critical moment for consumer protection in the technology environment (EU Artificial Intelligence Regulation, 2021). This framework categorises AI applications based on their perceived level of risk. However, as companies navigate this new regulatory landscape, several critical considerations are worth examining. For example, implementing the requirements outlined may entail significant financial investments for companies, particularly smaller businesses and startups with limited resources. At the same time, it should also be recognised that this approach is not a rights-based approach but a risk-based approach (Masse et al., 2023) in terms of fundamental rights. It will require rapid and sustained intervention to keep pace with the violations (Masse et al., 2023).

A key element of the approach is the creation of a rebuttable 'presumption of causation', which places the burden on companies to prove that AI systems have not caused harm to EU consumers. It means that AI is **liable** for harm unless proven otherwise. The Directive also promotes transparency and accountability by empowering national courts to order companies to disclose evidence relating to high-risk AI systems suspected of causing harm. This approach risks slowing down companies that want to make their mark in the innovative field (Artificial Intelligence Liability Directive, 2023).

Table 5. Risk-based approach

Art. 5 - Unacceptable Risk (Prohibited)	AI systems threaten safety, livelihoods, or rights (e.g., government social scoring or toys promoting risky behaviour).
Art. 6 - High Risk (Conformity Assessment)	Education, Employment, Justice, Immigration, Law.
Art. 52 - Limited Risk (Transparency)	Chat Bots, Deep Fakes, Emotion Recognition Systems.
Art.69 - Minimal Risk (Code of Conducts)	Spam Filters, Video Games.

Source: European Commission (2023).

But when legal standards require greater **transparency and accountability**, how can a company comply while protecting its private business information? To ensure this business information remains intact in this environment, companies can protect themselves under trade secret systems by fulfilling certain criteria (Meyers, 2019). These include the commercial importance of this business information, its limited access to a selected group of people, and the owner's diligent efforts to maintain the confidentiality of the information - as exemplified by practices such as non-disclosure agreements (Belciu, IP & IT Lawyer, 2023).

The existence of these **intellectual and industrial rights** can be seen as one of the most important drivers of innovation and strong market structures in the world, and the regulations being made in the field of intellectual property will deeply affect the artificial intelligence sector (Belciu, IP & IT Lawyer, 2023).

AI tools rely on sophisticated algorithms and refined data. It is worth noting that while algorithms themselves are not protected by copyright, the actual source code can be protected under EU copyright law (Belciu, IP & IT Lawyer, 2023). This distinction has important implications for innovators working on AI, as many companies have copyrighted AI code. The joint use of such code and the ownership of the code or other works produced using AI raises further questions, such as the ownership of the code or other works produced using AI. In a work created using AI, the user's contribution to the creative process may only be to press a button to enable the machine to do its job (Guadamuz, 2017). Granting copyright to the person who made the operation of artificial intelligence possible seems to be the most sensible approach (Guadamuz, 2017). Such an approach would allow companies to continue to invest in technology with confidence, knowing that their investment will pay off, but it could also mean that copyright law moves away from standards of originality that reward skill, labour and effort.

Conclusion

The regulatory environment for AI is diverse and evolving. The EU, the USA, and China have different approaches, each with strengths and weaknesses. The EU prioritises consumer protection through strict regulations that potentially inhibit innovation. In the US, the focus is on encouraging innovation while balancing consumer protection. China effectively incentivises local innovation and protects consumers by combining ethical concerns with strict control. It is vital that global regulators skilfully balance innovation and consumer protection to adapt to the rapid development of AI. International cooperation should standardise AI regulation for global challenges and promote and aim for responsible AI innovation for societal benefit.

In their adaptation, regulatory bodies face barriers in AI, especially with large datasets and acquisition complexities. Unequal access to data makes competition even more difficult. AI-driven supply and demand manipulation raises concerns in some markets. Solutions include redefining market dominance, transparent data practices, and potential AI-specific pricing regulations. Here, establishing accountability mechanisms for ethical business behaviour is crucial. AI-specific pricing and special laws have become necessary.

In this context, legislators' normative rule-making processes are in a state of uncertainty. In the risk-based approach taken by EU legislators, the minimum level of standards for all basic models should only apply if the model is used in a truly high-risk application. The categorisation procedure should be conducted with extreme caution since innovation and growth can be stifled on pretence.

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THE USE OF ARTIFICIAL INTELLIGENCE IN SLOVENIAN COMPANIES: MAIN FACTS AND RESEARCH AGENDA

Introduction

In 2023, generative artificial intelligence (in continuing AI) contributed to a resurgence of optimism about the positive impacts of technology on future productivity growth, the potential impact of technology on human well-being as well as its capacity to drive *"sustainable, inclusive growth, and solve complex global challenges"* (McKinsey, 2023a, p. 4). The future of European growth will largely rely on leveraging the use of AI and other technological advancements as increasing quality efficiency, introducing new forms of work, an ageing society, focusing on diversity, equity, and inclusion, as well as increasing resilience in the volatile global environment challenge the companies (McKinsey, 2023b) to enhance their capabilities, efficiency, and agility.

This chapter highlights the situation in Slovenia in comparison with other EU countries in 2021. It provides a more detailed sectoral comparison using official statistical data, which is based on a standardised methodology, with two purposes: (1) to provide a comparative overview of AI use across countries and sectors and (2) to provide a research agenda based on the findings of this official data analysis. The methodology used in official statistical analysis is specific, and all data should be interpreted in the context of the methodology (Box 1). It must be stressed that this data has a different focus than those collected by the "Jožef Stefan" Institute, used in Marinšek et al. (2023) and Požun et al. (2023). Those data also highlight the potential of AI development in Slovenia and rely on specific methodology.

The most recent available data for 2021 show that the use of artificial intelligence tools was most intense in Denmark (Figure 1), where more than a quarter of companies with at least ten employees used at least one of the AI tools. Surprisingly, Slovenia, with almost 12 percent, ranked 6th in EU-27, after Denmark, Portugal, Finland, the Netherlands and Luxembourg, which raises doubts about the survey methodology used to collect data for understanding the use of new (complex) technologies, especially if compared with other surveys (Požun et al., 2023). Generally, in 2021, the majority of companies that used AI used it to identify objects and individuals, mainly for safety and security. Natural language process technologies were used only in a percent of companies, similar to machine learning. The generative AI, ChatGPT, and other similar tools caused a fundamental shift in recognition of AI tools' potential and, in 2023, the situation should be significantly different.

The chapter first provides an overview of the use of AI in Slovenia compared to the EU and a comparative analysis of industries and technologies in Slovenia. To investigate the current situation, an extensive case study analysis was done.

1 The use of artificial intelligence in companies in Slovenia and the EU

Eurostat and Statistical Office of the Republic of Slovenia gather data using a standardised approach and definition of AI tools (Box 1). In some cases, as technology develops fast, an increasing number of companies may find some simpler tools, which are becoming increasingly (e.g., recognition tools) less relevant in terms of productivity impact – they will become a 'standard'. Therefore, in the data, the percentage of use of certain tools increases fast; however, from the comparative perspective of AI use intensity, these tools become less important. At the moment, this could already include Google Translate, Apple Siri, and some others, which likely many already use. The lack of differentiating between standard and more complex AI tools blurs the line between the early AI adopters and the followers. Therefore, all data in continuing should be interpreted in line with the definition of AI used (Box 1).

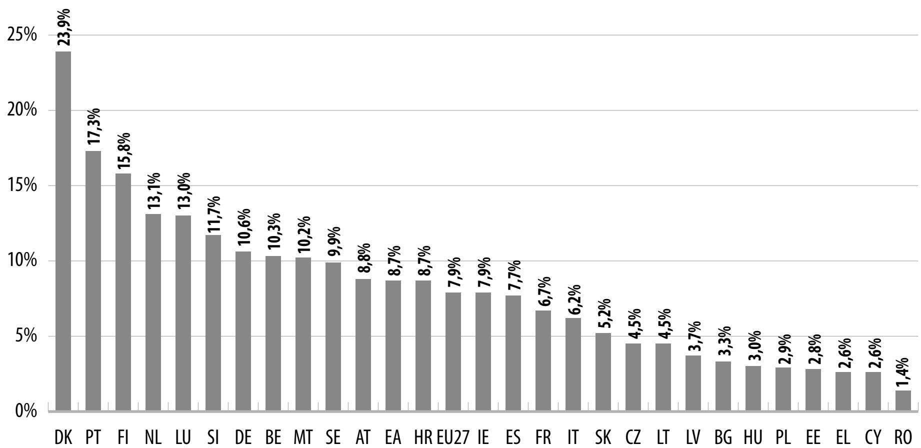
On average, 7.9 percent of EU-27 companies were using AI in 2021, according to Eurostat (2023) data (Figure 1). The use of AI was highest in 2021 in Denmark, where almost a quarter of companies reported using AI. In Slovenia, 11.7 percent of companies with at least ten employees were using AI in 2021, which ranked Slovenia 6th among all EU economies. The use of AI was lower in less developed EU countries. In Romania, only 1.4 percent of companies were using AI. The data for Slovenia for 2023 shows that the use of AI remained similar, with 11.3 percent of companies using AI.

Box 1. Definition of AI tools used in the survey on the 'Use of ICT in companies'

- **Image-based object or person recognition technologies** (e.g., product recognition, fingerprint, face, object, and video). Examples of such technologies are: (1) computer vision, which captures, processes, analyses and interprets images; (2) machine vision, which enables product recognition and product quality control; and (3) video analytics. Also, consider biometric methods to unlock smartphones or other devices (fingerprint, facial recognition) if used in the company.
- **Technologies that analyse written languages (text mining)**. Text mining is the process of converting large amounts of text into useful information for different purposes. Natural Language Processing (NLP) is an example of such a technology.
- **Technologies that convert spoken language into a machine-readable format** (speech recognition). These include using digital assistants such as Google Voice, Amazon Alexa, Microsoft Cortana, and Apple Siri.
- **Technologies that generate written or spoken language (natural language generation)**. These technologies allow speech recognition and translation from one language to another (e.g., Google Translate). They can be used for automated document writing, e.g., product descriptions and meeting notes (transcription on the fly). Another example of an application is a chatbot. This artificial intelligence-based robot enables text-based communication with customers based on methods such as natural language generation and machine learning.
- **Machine learning (e.g., deep learning) to analyse data**. Machine learning is a method where algorithms are used to create a model (e.g., decision trees or regression model) for data analysis or prediction. It is used, e.g., in recommender systems for online sales, dynamic price adjustment, predictive maintenance, advanced analytics for sales forecasting, distribution optimisation, inventory optimisation, detection and prevention of cyber attacks.
- **Technologies that automate different workflows or provide decision support.** Intelligent automation (Robotic Process Automation – RPA using artificial intelligence) is a solution where software robots automate business processes, e.g., opening an email attachment or scanning prices from websites.
- **Technologies that enable the physical movement of machines with autonomous decision-making based on observation of the surroundings** (e.g., autonomous robots, self-driving vehicles, and autonomous drones). These include, for example, robots that use machine learning or self-driving vehicles that use a combination of machine learning and computer vision to drive safely. Autonomous robots are intelligent machines that can perform tasks on their own, e.g., in warehouses.

Source: Statistical Office of Republic of Slovenia (2019).

Figure 1. Percentage of companies with at least ten employees using AI in 2021



Source: Eurostat (2023).

The intensity of the use of AI significantly changes with company size. On average, among small companies in the EU, around 6.4 percent were using AI, while among large companies, over 28 percent used AI in 2021 (Table 1). Data for 2023, available for Slovenia, shows that the intensity increased significantly among large companies, where already more than half were using AI.

Table 1. Percentage of companies using AI technologies by size class in 2021 for EU countries and 2023 for Slovenia

	At least 10 employees	10 to 49 employees	50 to 249 employees	250 or more employees
EU-27	7.9	6.4	12.8	28.5
Austria	8.8	7.1	14.6	31.7
Croatia	8.7	8.1	9.9	21.5
Czechia	4.5	2.7	7.6	24.4
Denmark	23.9	19.7	37.3	66.2
Finland	15.8	12.4	26.7	51.2
Germany	10.6	8.9	14.8	30.9
Italy	6.2	5.3	10.0	24.3
Slovakia	5.2	4.1	7.0	19.4
Slovenia	11.7	9.4	19.8	36.4
Sweden	9.9	7.6	18.1	40.3
Slovenia (2023)	11.4	8.9	16.8	53.2

Source: Eurostat (2023), Statistical office of the Republic of Slovenia (2023).

The use of AI differs significantly among industries (Table 2). The data for EU-27 for 2021 shows that the use was most intense, as expected, in the sector J (Information and communication) and the ICT sector, where a quarter of companies in the EU-27 and close to 40 percent in Slovenia used AI already in 2021. In the ICT sector, the use of AI in Slovenia increased from around a third to over 40 percent of companies. Among services, the use of AI was very intense also in professional, scientific, and technical activities, where around 17 percent in the EU-27 and 18 percent in Slovenia used AI in 2021. In Slovenia, this share increased between 2021 and 2023 to more than a quarter of firms.

Table 2. Percentage of companies using AI in 2021 by industry

Code	Industry	EU-27	Slovenia	
		2021	2021	2023
C10-C18	Manufacture of products based on food, beverages, tobacco, textile, leather, wood, pulp and paper; publishing and printing	5.5	6.9	6.1
C19-C23	Manufacture of coke, refined petroleum, chemical and basic pharmaceutical products, rubber and plastics, other non-metallic mineral products	8.9	20.9	16.8
C24-C25	Manufacture of basic metals and fabricated metal products, except machinery and equipment	6.2	11.9	9.2
C26-C33	Manufacture of computers, electronic and optical products, electrical equipment, machinery and equipment n.e.c, motor vehicles, other transport equipment, furniture, other manufacturing, repair and installation of machinery and equipment	9.3	13.4	22.2
D-E	Electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities	9.0	10.7	10.4
F	Construction	4.8	4.2	4.0
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	5.8	5.2	3.3
G46	Wholesale trade, except for motor vehicles and motorcycles	6.8	12.3	18.2
G47	Retail trade, except for motor vehicles and motorcycles	6.3	12.2	20.2
H	Transportation and storage	5.3	12.5	7.5
I55	Accommodation	5.6	6.7	5.1
J	Information and communication	25.5	39.6	33.4
M	Professional, scientific and technical activities	17.6	18.6	25.8
ICT	Information and communication technology - total	24.8	33.6	40.8

Source: Eurostat (2023); Statistical office of the Republic of Slovenia (2023).

Among other industries, the use of AI was also high in the manufacture of computers, electronic and optical products, electrical equipment, machinery and equipment, other transport equipment, furniture, other manufacturing, repair and installation of machinery and equipment, where on average more than 9 percent of companies used AI. This group was followed by industries NACE D and E, which represent electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities with 9 percent and the industries C19-2, i.e. the manufacture of coke, refined petroleum, chemical and basic pharmaceutical products, rubber and plastics, other non-metallic mineral products, where just below 9 percent of companies were using AI. The percentage of companies using AI in Slovenia in C19-C2 was significantly above the EU average in both observed years, around double the share. In 2023 it was, besides in ICT, highest in the manufacture of computers, electronic and optical products, electrical equipment, machinery and equipment, other transport equipment, furniture, other manufacturing, repair and installation of machinery and equipment (C26-C33), where on average more than 22 percent of companies used AI, followed by retail trade (G47), where every fifth company was using AI.

Table 3. The purposes of AI use in companies using AI

	2021	2023
Number of all companies and number of users		
Number of enterprises	7,712	8,576
Enterprises using artificial intelligence technology	905	975
Percent of companies that use artificial intelligence		
Enterprises using artificial intelligence technology	11.7	11.4
For marketing or sales	3.1	2.4
For production processes	3.0	2.8
For logistics	1.0	1.2
For ICT security	8.0	7.8
For the organisation of business administration processes	1.6	N/A
For management of enterprises	2.4	N/A
For human resource management or recruiting	0.3	N/A
For the organisation of business administration processes or management	N/A	2.2
For accounting, controlling or finance management	N/A	1.7
For research and development (R&D) or innovation activity	N/A	2.4

Source: Statistical office of the Republic of Slovenia (2023).

Companies in Slovenia that used AI, which was only around 11 percent of companies, used it most often in ICT security – 7.8 percent of all companies report using AI in ICT security. In 2023, artificial intelligence was also used in production processes (2.8 percent of users in 2023) and in marketing and sales, R&D and organisation and business administration processes, where around a fifth of users used AI (Table 3).

Interestingly, among almost 90 percent of companies that are not using AI, only a small fraction considered using AI, around 8 percent in 2023 (Table 4). These companies, which have thought of using AI, but decided against it, list as the most important reasons for not using AI: the perceived high costs (54.4 percent), lack of relevant expertise in companies (53.8 percent) and difficulties with availability or quality of the necessary data needed by artificial intelligence technologies (51.4 percent). Incompatibility with existing software and technology and data protection are also important reasons.

Table 4. The causes of not using AI in companies that have considered using AI

	2021	2023
All companies and all non-users		
Number of enterprises	7,712	8,576
Enterprises not using artificial intelligence technology	6,766	7,357
All non-users who considered using AI		
Number of those who have considered using artificial intelligence technologies	454	580
Percent of those who have considered using artificial intelligence technologies as a percent of all companies	6.7	7.9
Reasons for not using AI among companies that have considered using AI		
The costs seem too high	66.7	54.5
There is a lack of relevant expertise in the enterprise	63.0	53.8
Incompatibility of these technologies with existing equipment, software or systems	57.9	48.3
Difficulties with the availability or quality of the necessary data needed by artificial intelligence technologies	50.9	51.4
Concerns regarding violation of data protection and privacy	23.3	42.8
Lack of clarity about the legal consequences, e.g., liability in the case of damage caused by the use of artificial intelligence	25.3	44.0
Ethical considerations	16.3	18.3
Artificial intelligence technologies are not useful for the enterprise	23.3	32.8

Source: Statistical office of the Republic of Slovenia (2023).

Despite the surge of interest in artificial intelligence in 2023, the actual use remains low, especially among small companies. Even more surprising is the low percentage of non-users who considered using AI. More than 90 percent of non-users do not even consider using AI technologies in the future. As AI is an essential driver of digital servitisation, the companies that will incorporate AI technologies in their business model will prosper in the future. Showing no interest in using AI might either signal low AI capabilities in the companies (data pipeline, algorithm development, and AI democratisation) or a lack of a well-functioning business ecosystem (Sjödin et al., 2021).

2 Research background

Companies employ AI technologies for many different purposes. They are thus using various tools, from text mining for language analysis, speech recognition for converting spoken language to machine-readable text, natural language generation for generating written or spoken language, image recognition and processing for identifying objects or individuals, machine learning techniques, including deep learning, for data analysis, AI-based software robotic process automation for workflow automation and decision support, technologies enabling physical machine movement via autonomous decision-making, such as autonomous robots, self-driving vehicles, and autonomous drones (Eurostat, 2018).

The use of AI is expected to increase fast both in terms of types of technology used as well as purposes of use. This prediction is evident already from the recent technology trends and the expected impacts on firms' productivity, competitiveness, efficiency, cost, management, innovation and many other aspects (Osei-Assibey Bonsu et al., 2023; Broekhuizen et al., 2023; Czarnitzki et al., 2023; Krakowski et al., 2023; Mikalef et al., 2023; Rozman et al., 2023; Zhong et al., 2023).

Technologies are being used in marketing, sales, R&D processes, production, quality control, logistics, value-chain management, accounting, decision-making and many other functions and processes (Bodendorf et al., 2023; Mikalef et al., 2023; Mishra et al., 2022; Prikshat et al., 2023; Wu & Monfort, 2023). The use is expected to increase due to the foreseen advantages in terms of efficiency, cost and many others.

The use of AI technologies in EU countries is, at the moment, still relatively low due to low investment in AI technologies in the past. The US, for example, spent nearly twice as much as the EU (and 2.7 times more on a per capita basis) on AI R&D and AI-related complementary assets from 2018 to 2020 (Evas et al., 2022). The adoption of new technologies also faces several obstacles, which are common also in the case of AI. Among the most common are those already listed in the analysis of existing Eurostat data. These are first the lack of AI knowledge and expertise, limited understanding of AI, resistance to change, and cultural and leadership barriers at the firm level (Čater et al., 2021; Černe et al., 2023; Erol et al., 2016). The costs, scalability, uncertainty about the actual impact on firm performance, the challenges of integrating AI into existing IT systems and processes, and questions of data quality and availability matter (Heath, 2023; Oltmans, 2023). Legal barriers and ethical concerns impact the uncertainty regarding AI due to non-existing legal frameworks (Eroglu & Kaya, 2022; Prentice et al., 2023; Quach et al., 2022), while security risks (Cheatham et al., 2019; McKinsey, 2023a) as well as general global macroeconomic trends further expose companies to risks, which could either deter them from fast adoption or even, to deal more easily with risk, stimulate adoption.

3 Research agenda and methodology

The goal of the research in the following five chapters was to gain a comprehensive understanding of the complexity of AI implementation in companies that goes far beyond official statistics on the use of AI technologies, as well as observed impacts and obstacles. First, the supply side of AI in Slovenia was studied, focusing on the characteristics of suppliers of new AI-based solutions to companies and then the use of AI in four companies (Telekom Slovenije, Salus, iProm and Kolektor Mobility) was examined. These four cases cover both manufacturing and services. Kolektor Mobility is a significant provider of solutions in the automotive industry that faces important developmental issues related to digital transformation (Končan et al., 2023) and represents an important sector in terms of GDP production in Slovenia. As a first runner in the field of using AI technologies in the production process in Slovenia, Kolektor Mobility developed the Qlector LEAP AI platform for production, guiding its manufacturing processes (Qlector, 2023). This platform, developed by Qlector – a portfolio company of Kolektor, closely affiliated with the research community, notably the Artificial Intelligence Laboratory at the "Jožef Stefan" Institute – utilises artificial intelligence to assist discrete and process manufacturers facing challenges related to transparency gaps, suboptimal resource utilisation, and tacit knowledge capture (Cirman et al., 2023). These AI-generated shop-floor solutions represent an important part of the new services that Qlector offers to other companies. Salus is an example of a company in the wholesale sector, representing around a tenth of GDP. It is also a sector where digitalisation due to process optimisation is crucial and will contribute to new business model development in the future. Telekom Slovenije, the representative of the information and telecommunication sector, is the major telecommunication provider in Slovenia. They embarked on the AI transformation journey not only by implementing several solutions in their business processes but also by developing several new services based on AI solutions for customers. Their digital and AI competencies are leveraged for developing new business solutions, especially those related to cybersecurity systems. This accomplishment points to the wide applicability of AI-related skills to diversify into related markets. Company iProm is a company from the marketing industry, the industry that is going to be under immense pressure in the age of AI. The company is very interesting because they introduced AI tools a decade ago and are being used intensely in customer analysis, segmentation, support, etc.

The case studies were all prepared using a standardised approach – a set of pre-defined open-end questions for managers at different positions in the company (general management, IT, HR, R&D, marketing, sales, finance, ICT, logistics, production, etc.) which were used as a guide during interviews. The data was collected through qualitative interviews using these questions as a base. If needed, the questions were adapted to the characteristics of the company.

Generally, the analysis focused on the following aspects: (1) the new technologies (e.g., robots and AI) companies use and how long they have been using them; (2) the current state of the industry's use of AI and other new technologies, both within the industry as a whole and among its main competitors; (3) the implementation process for these technologies, along with details regarding the primary expectations about their positive impacts, potential concerns, and the main obstacles; (4) the perceived impact of AI and other new technologies on the company's overall business strategy, business models, as well as its short and long-term goals, firm performance and competitiveness; (5) the expected benefits of using AI and other new technologies at the firm level, as well as any negative effects or obstacles encountered during implementation; (6) legal and regulatory aspects, especially concerning AI, and ethical considerations and responsible use of AI technologies within the company.

For specific business functions (HR, IT, R&D, logistics, etc.), the analysis focused on the types of AI tools used in the specific functions and challenges in implementation, depending on the nature of the main tasks within a particular business function. For example, the HR Manager was asked first which of the new technologies, solutions, and programs they use and if any AI-based solutions are being used. Similarly, as with all others, the process of adoption was examined. But due to the nature and role of HR, the interview primarily examined whether AI affected talent acquisition and recruitment processes in the company, if AI-driven solutions were being used to enhance employee engagement, performance management, and training, how companies address concerns about AI's impact on job roles and responsibilities among employees, what was the required change, adaptation, reskilling, reorganisation of work in terms of human resources. In the case of HRM, it was also vital to ensure acceptance among employees. Thus, possible worries, fears, resilience, and readiness to adopt were investigated, as well as how companies dealt with both positive and negative aspects of human resource reaction to the implemented/adopted AI solutions.

IT also has a specific role in AI adoption. Therefore, besides focusing on the general issues of what is being used from the set of new technologies and which are, if any, AI-based, there were also questions on the implementation process, obstacles, and perceived and actual results, so the analysis focused on selected specific IT-related issues. First, the most critical challenges and opportunities in implementing AI solutions into the existing company's IT infrastructure were explored, followed by the process of managing the integration of AI technologies with existing systems and processes as well as other technologies used in the company, how important obstacle the integration aspect is also in the decision for AI use. The analysis also investigated to what extent the regulation is a challenge in AI implementation, as well as data security and cybersecurity and how companies manage that.

In production, besides again asking general questions, the analysis also explored what AI-driven solutions are used to optimise production efficiency and quality control, what effects companies noticed, and possible challenges in the use and implementation. The analysis also explored how companies address concerns about job displacement and upskilling of the workforce due to new technology, robots, and AI integration. In addition, due to possible upskilling and reskilling challenges, it was important to understand which specific HR-related challenges they faced in production and how much training was done.

In supply, marketing and sales, the analysis also explored whether AI has transformed marketing strategies and customer engagement efforts, which AI-powered tools or technologies were used for data analytics regarding customer characteristics, market analysis, competitor analysis, etc. Concerning customer analysis, it was vital to understand how companies ensure ethical, transparent data collection/analysis as well as communication, how that (if at all) affects customer trust when using AI in data collection, and also (if) in marketing campaigns. In terms of supply, the analysis also explored how AI has changed the procurement process, how it changes the collaboration and communication with suppliers, which technologies or AI tools suppliers use, etc.

In R&D, the analysis explored which AI applications or tools companies have integrated to enhance product development and innovation and the impact on actual R&D processes and innovation. It was important to understand how companies ensure cooperation between R&D teams and AI experts to use AI and other new technologies effectively and what were the required changes, adaptation, reskilling, and reorganisation of work in terms of human resources.

Conclusion

Technological development is moving at an exponential pace, and the recent generative AI boom will only accelerate the process of AI adoption due to wider awareness of AI's potential (not only of generative AI but all AI-based technologies). Currently, the use of AI is still relatively low, and often, companies are careful in adopting new, possibly costly solutions with uncertain impact. Although the official statistical data show that Slovenia is comparatively doing well with respect to the use of AI in companies, the visits to the companies revealed that the use of AI is at the beginning stages, with a minimal impact on the firm's performance. To fully understand the impact of AI on firms and, consequently, the intended and actual use, the case study approach was used in the following chapters, as it allows an in-depth analysis of each company, and the findings can serve as a foundation for future research.

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FROM LAB TO MARKET: EXAMINING THE SUPPLY DYNAMICS OF AI TECHNOLOGIES IN SLOVENIA

Introduction

With the recent advancement of Industry 4.0, the business environment is becoming more and more data-driven. Vast amounts of data are being provided every second. Consequently, the environment has become increasingly dynamic, connected, and interdependent, so much so that it has exceeded the extent to which humans can keep up with the information flow. Artificial intelligence (AI) carries the potential to revolutionise how decision-making is performed in companies throughout all industries with its ability to create predictive analytics. Besides allowing humans to grasp and understand the vast amounts of data provided from various sources at high speed, AI also contributes to increased productivity and effectiveness (Peres et al., 2020).

The number of active AI start-ups in the world has increased by a factor of 14 since 2000. On top of that, 84 percent of enterprises believe that investing in AI will lead to greater competitive advantage, 75 percent of them have confidence that technology will open a new market opportunity for them, and 63 percent of them believe that the new technology will reduce costs (Forbes, 2018). Considering these details, the market for AI suppliers possesses an enormous potential for growth, and in this chapter, the suppliers of AI solutions in Slovenia will be analysed.

The chapter begins with an overview of the AI suppliers, encompassing a concise definition and current market landscape. The empirical section focuses on AI solution providers in Slovenia, beginning with their perspectives on AI, its societal role and its potential future purpose. The analysis then delves into the status of the Slovenian AI technology market, its evolving trajectory and the shared characteristics of customers seeking AI solutions. Additionally, it inspects the obstacles that hinder the exponential further development of AI solutions in Slovenia. The last part of the empirical analysis looks at the role of the state in the rapidly developing AI market and the general outlook for AI subsidies and grants provided by the EU. The final part summarises key findings and concludes the chapter.

1 Artificial intelligence suppliers

By definition, a company that is supplying products or services empowered with AI technology to the market for general usage is called an AI company or an AI supplier. The same term is also used for companies that specialise in integrating custom-made AI solutions to help other companies improve and remain competitive in their industry (Stand8, 2023). AI solutions have been altering many different industries, which can be evidenced, for example, in the case of Airbnb and Uber. When companies embrace the usage of artificial intelligence in their processes, their business model changes as well, making the general population see AI as the catalyst of business model innovation. Although the new technology might not yet be fully understood, many companies are being made vulnerable to competitors equipped with AI technology (Lee et al., 2019).

The latest global survey conducted by McKinsey indicated a massive growth of generative (genAI) tools, which were introduced less than a year ago. Nowadays, one-third of survey respondents confirmed using genAI tools in at least one of their business functions. These kinds of tools are especially used in companies working in technology, media, telecommunication industry and financial services. Geographically, the new tools are mostly used in Greater China and Europe (McKinsey & Company, 2023).

New technology always comes with some companies not fully embracing it. From the survey, the biggest risks listed were inaccuracy, cybersecurity, intellectual property infringement, and regulatory compliance. This kind of fear can cause some companies to be left behind in the fourth industrial revolution. Businesses embracing AI technology in their processes early mostly plan to increase the value of offerings by integrating artificial intelligence and increasing revenue from core business (McKinsey & Company, 2023).

As with any other big revolution, it brings many changes to the company structure and business model. AI ambitions are causing changes in roles that organisations are filling to support their advancements. In the past year, companies mostly hired data engineers, machine learning engineers, and AI data scientists. In the majority of occurrences, companies did not have a big fluctuation in the size of the workforce, or they decreased the number of their employees by three to ten percent. But almost 38 percent of all respondents stated that more than 20 percent of all employees are expected to be reskilled (McKinsey & Company, 2023).

The revolution into the Industry 4.0. boosted by AI technology targets the decrease in costs and the revenue increase for companies using it. The most significant cost decreases in 2022 were recorded in service operations, strategy, corporate finance, and manufacturing. On the other hand, the biggest increases in revenues were recorded in manufacturing, risk management, and R&D (McKinsey & Company, 2023).

In summary, McKinsey's survey indicates significant adoption of genAI tools in various industries, though concerns like inaccuracy and cybersecurity persist. Companies embracing AI are focusing on reskilling their workforce and reaping cost reductions and revenue growth, particularly in manufacturing and research and development. AI continues to shape the business landscape of Industry 4.0, which presents a market full of potential for AI suppliers, also in Slovenia.

2 Empirical analysis

The industry and phenomenon of AI are not so new; however, the understanding and AI proficiency of the general public are still very low. It is, therefore, of no surprise that the availability of research papers on the topic of AI supply, in Slovenia especially, but in Europe as well, is also scarce, and vice-versa, affecting the education on the subject.

The breakthroughs in the last decade are all based on vast improvements in computational power and increased data quantity available, allowing for AI system training and enabling the application of AI to an ever-wider range of sectors and purposes (Engelke, 2020). As with everything else, transformation takes time as well. AI could transform how people live and do their jobs (The Economist, 2023). But the road to widespread diffusion and any resulting productivity boom will be a long one.

2.1 Research methodology

In total, 17 semi-structured in-depth interviews were conducted to explore how AI providers perceive AI technology, its potential impact on business and society, and the varying needs of their clients. This interview style was chosen because it allowed us to focus on understanding the interviewees' perspectives rather than attempting to generalise their experiences. These interviews, ranging from 42 to 93 minutes, were conducted between August 23 and September 7, 2023, at the companies' headquarters. To gain a comprehensive market perspective, a diverse range of companies was interviewed, including small firms and large international corporations serving various industries. The selection criteria considered organisation size, product/service offerings, and industry focus. The mentioned characteristics for the 17 participating companies can be found in Table 1.

Interview questions were structured into six subtopics, each addressing specific aspects of the AI supply side in the Slovenian market. The following research questions aim to comprehensively explore the perspectives of AI providers in Slovenia and draw meaningful conclusions, which will be discussed and answered in the coming sections.

1. How does a supplier's perception of AI impact its role in modern society and its purpose in the future?

2. What is the current state and the future trajectory of the Slovenian AI technologies market?

3. What common characteristics are shared among clients seeking AI solutions?

4. What are the primary obstacles hindering the exponential growth of AI solutions in this research area?

5. What is the role of government policies and legislation in shaping the rapidly evolving AI market?

6. What is the overall sentiment regarding EU-provided AI support subsidies and financial assistance?

The main findings regarding the six research questions are summarised at the end of the chapter in Table 2.

Table 1. Sample firm characteristics

Code	Size	Served sectors/Offerings	Product or Service	Interviewee's position	Interviewee's gender
AI-1	Small	Optimisation & digital transformation	Product	CEO	Male
AI-2	Small	Computer vision & speech technologies	Both	CEO	Female
				CTO	Male
AI-3	Small	IT business solutions	Product	CEO	Male
AI-4	Micro	Energy sector	Both	CEO	Male
AI-5	Micro	Global media	Product	CEO	Male
AI-6	Micro	Medicine & disease diagnostics	Both	CTO	Male
AI-7	Micro	Productivity software	Product	CEO	Male
AI-8	Micro	Logistics	Product	CEO	Male
				CTO	Male
AI-9	Micro	Biopharmacy & biotechnology	Product	CEO	Male
AI-10	Small	Media & advertising	Both	CPO	Male
AI-11	Large	Gaming industry	Product	Project and Department Manager	Male
AI-12	Micro	AI consultancy	Service	CEO	Male
AI-13	Micro	Supply chain management	Both	Managing Director	Female
AI-14	Micro	Big data management	Both	CTO	Male
AI-15	Medium	Computer vision systems	Both	CEO	Male
				Product Manager	Male
AI-16	Medium	Remote sensing & ML	Both	CEO	Male
				Senior Data Scientist	Male
AI-17	Micro	Logistics, mobility, leisure	Both	CEO	Male

Source: Own work (2023).

2.2 AI and its effects

There is not one widely agreed upon definition of artificial intelligence, but a variety of them. Though the general public commonly equates AI to automation, the potential of the discussed phenomenon does not end there. Concluding from the interviews, AI can disrupt industries and revolutionise people's daily lives. *"In the Industrial Revolution, we substituted our muscles with machines, and right now, we are substituting our brains with machines. So, we are be-*

coming much more capable of completing new tasks" (AI-8). The interviewees provided examples of significant improvements made possible by AI. *"Many vulnerable groups of users can benefit hugely from AI systems, such as blind and visually impaired people. As we are building speech synthesis systems, they are now able to read the information that is available in a digital form"* (AI-2).

Researching the technology's potential through conducted interviews highlighted the following: "*AI is just a tool, so it is just something that I believe can now solve problems that previously were not solvable at scale"* (AI-9). The latter was repeated numerous times during the interviews, confirming that, as with any other technology, AI development is also driven mainly by the consumer needs currently and expected to be present in the market. Seeing there was a need to drive the development of the technology, there was only a catalyst missing. *"The computer processing power increased very much, and we had the data available for the first time, enough data to train some more advanced machine learning mechanisms like, for example, deep neural networks"* (AI-2). The availability of computing power and the potential to take advantage of the latter to satisfy the newly developed customer needs to pave the way for further development of the technology. *"Advancements in the speed and the memory and all of those technological things allowed great growth of this kind of technology"* (AI-11).

The AI industry quickly focused on specialising in certain fields and supplying companies catering to niche AI markets. *"I think that everybody who will develop specific solutions will do it for certain verticals, for example, manufacturing, insurance companies and so on. In developing specific solutions, the technology and domain knowledge will need to be combined"* (AI-13). The idea that the development of AI will become specific to the industry indicates a shift from large multinational companies developing general AI solutions for the mass market into the favour of smaller suppliers. *"There are a lot of big companies. And when we talk to them, we see we have the speed to keep up with all these changes that they do not. And I think this is where a kind of synergy between us and them, not fighting against each other, is formed"* (AI-8).

Should these smaller firms integrate their solutions into the specifics of each sector more effectively, it would give them a competitive advantage, allowing them to prevail in the long run. *"AI was a means of diversification for us, as we did not want to be dependent on only one customer and industry. Now, we focus more on one industry and try to search for synergies"* (AI-17).

Based on the in-depth interviews, AI is not a very well-defined concept, and its understanding, therefore, depends on the industry's usage of the technology as well as the industry's perspective of its business potential. Every technology available today has benefits and drawbacks that, depending on the individual's perspective, outweigh one another. While its limits remain unclear, artificial intelligence is here to stay and will have an even more significant impact on people's everyday lives.

2.3 Market of Slovenian AI suppliers

Although the hype around AI is very present in Slovenia, and the current trend seems to be implementing AI in businesses, statistical data shows that only 12 percent of all Slovenian companies with more than ten employees use AI technologies (Eurostat, 2022). On a broader scale, Slovenian companies are more inclined to use and implement AI solutions in their companies than their European counterparts (Eurostat, 2022).

Knowing that only a minority of non-micro businesses in Slovenia take advantage of AI or AI-enabled solutions, and an even smaller percentage at the European level shows excellent potential and untapped market opportunities in the studied area. *"We have tried approaching some international companies, but we were not successful. We want to get clients from abroad, but we do not know how to reach to them"* (AI-14). *"It is difficult because you must localise; you have to know the specifics of a certain market. If you are selling in Germany, you must have a native. Unfortunately, sales representatives from a Slovenian company cannot sell by themselves in Germany. We are forced to do it this way; we have local people there who enter and open the door"* (AI-13). While the challenge of getting to the customer was pointed out as a big reason for the market potential being unused, other challenges were also unveiled. *"We have some problems with customer acquisition, as the cost of our solutions can be a major obstacle, especially for smaller companies"* (AI-14). The intricacy of most of the provided solutions comes with its price, which is commonly unbearable for smaller firms, as integrating AI solutions can be a substantial investment and may, therefore, pose challenges in customer acquisition. Stemming from the latter observation, companies must adapt their pricing policy to serve the market adequately. Companies try to provide a suitable price for their solution by examining their clients' needs and desires. *"We try to be very transparent with the pricing and have a dedicated segment on our site where you can see and decide for the tier of service that your company requires"* (AI-16). Organisations use either subscription-based pricing (SaaS or now AI-as-a-service), per product price, per project price – commonly consisting of hours worked or a combination of a few. *“We offer a monthly subscription-based solution, where customers subscribe to the plan that best suits their needs”* (AI-5). *“The hardware that we sell is equipped with the AI-backed software for the products, and we also offer maintenance contracts”* (AI-4).

The supply side of the market is not the problem for low AI implementation. Considering the untapped potential of the AI market in Slovenia and Europe as well, it can be concluded that the problem lies on the clients’ side. The growth potential is huge, and the market is growing and developing further, concurrent with the already vast and diverse supply of AI solutions covering various niche needs through a ‘sea of applicable solutions’. Therefore, the clients’ side of the analysed industry was investigated.

2.4 Clients and use cases of AI

With AI’s ability to be adapted and implemented in many ways into many different applications throughout industries, there is little to do in terms of characterising a client segment for AI technology solutions. *“Not having an ideal customer is kind of a challenge in itself”* (AI-5). The ‘persona’ of a client for AI solutions mostly refers to a client’s size, data availability and data quality rather than the industry in which they operate. *“The majority of our clients are governments and big companies. We occasionally also work with medium-sized companies. Small companies do not have the money to invest in tailor-made AI solutions”* (AI-3). *“I cannot say that there is a pattern from which fields companies come to us for solutions. So, lots of them. Probably where the big data exists, where there is an advantage to implementation, and the data in digital form exists”* (AI-1). Furthermore, software solutions, including AI technology, have long passed the stage where geographical location is problematic for providing products and services to clients. Research showed that there is still a tendency for suppliers of AI to operate in their domestic market more than internationally due to difficulties entering external markets. *“We have clients that are coming mainly from Slovenia”* (AI-14). While Slovenia is still the key market for many, some have successfully managed to penetrate international markets and are continuing to extend their connections and partnerships. *“We have clients from all over the world. For example, I think we have just a few clients from Slovenia. But Slovenia is so small, and even Europe is becoming a less representative region for us now”* (AI-5).

AI technologies are used in companies mainly to automate/ease certain tasks. This optimisation creates free time for employees to be more creative, look for new business opportunities, unleash their imagination and show their creativity to make further progress instead of doing repetitive tasks. *"If you use AI keeping the same tally of people, but you can create more output, you increase productivity and preserve your employees' employment. They can focus on creating more value"* (AI-11). *"Our solutions are not replacing the employees but helping them be more produc tive, and we also rely on their expertise"* (AI-17). In parallel, client companies implement AI technology into their business processes and operations for other obvious economic reasons besides automation. *"The reason for implementing is always the same: increase revenue or reduce cost. Those are the only two reasons"* (AI-9). *"They knew immediately how to benefit from that (AI solution) even while not understanding the technology. It was just a matter of, okay, if I get this, I can cut down costs here or make more money there, and that is how they see how it goes"* (AI-8).

Despite AI's extreme adaptability and ability to be used across several industries and scenarios, a universal solution does not exist. Therefore, personalisation to each client remains the key to exceeding expectations of what is possible with this technology. Depending on the industry, market and use case, no two problems are the same, so neither are the solutions. As such, these requirements for solutions are one of the more important drivers for the direction of development of AI technologies. Therefore, a complete understanding of their clients' needs is crucial and could be the key to potential competitive advantage. *"We are project-oriented, so we do not have products or sell products in a box. You buy a project, so you get a custom-tailored solution. It will differentiate you from other companies. It is not something out of the box"* (AI-3). *"We saw that investing in AI and developing AI solutions makes sense because we can increase the portfolio of offerings and offer the solution to the customer"* (AI-4). On the contrary, some suppliers offer AI as a ready-to-use product. They reckon that developing some generally applicable AI solutions is market feasible, viable and potentially even scalable, which is one of the reasons these AI suppliers enter the market.

Before customers can be acquainted with AI solutions offered on the market, these clients must first be acquired. Where this becomes a significant concern for suppliers and their ability to offer their services on a wider scale is trust regarding AI technologies and their functionality. Difficulties obtaining clients were one of the key touchpoints on this topic in several companies. *"First, clients need to trust AI solutions. So that is, I think, the biggest challenge we have now. When you get a system that works instead of you for some parts, you do not* *trust it at first"* (AI-8). *"What we need to do business successfully is, first and foremost, trust. Then there are lots of tests, questions, documents that need to be sent and so on. It is not like, if you give me a ten percent discount, I will buy it. It is a complicated process. There is also not just one decision-maker, there are many and so on. So, the decision-making process is long, and the amount of information shared is huge"* (AI-15).

The long process is partly due to the lack of knowledge on clients' side before their contact with AI. *"So, none of them necessarily know anything about the technology behind it, but they know what they want to get from it"* (AI-8). *"You have to educate clients from scratch, from the beginning... The situation and actual environment are such that a lot of companies run their manufacturing operations on Excel. They may have ERPs, they may even have manufacturing execution systems, but they use whatever it takes to make their work easier and sometimes an Excel sheet is the easiest way to run the production. This is basically our reality"* (AI-13).

Similarly, the overuse of AI as a buzzword has negatively impacted the demand for AI solutions in the experiences of suppliers. *"There is already a bit of AI fatigue, which means many people think: "Oh, another AI something tool". So, I think we are starting to near the end of this first wave of excitement, and it will get more and more difficult to make people really excited about your AI product"* (AI-9).

Presented information compiles into a strong case for AI solutions being a customer-driven market with suppliers needing to adapt heavily to customers' demands. Potential customers have to be approached by suppliers and educated on the applications of AI with a strong emphasis on delivering preconceived results. Considering the widespread application possibilities of AI combined with many industries, the specialisation of AI development into specific sectors and the belief of clientele that solutions should not be shared among competitors presents a strong case in the direction of custom-developed solutions. The major touchpoints that clients are looking to improve with the use of AI are the automation of tasks, potentially lowering costs and gaining additional revenue.

2.5 Obstacles affecting growth

The biggest obstacle affecting AI growth is the lack of trust in new technologies and the clients' knowledge of AI. These combine into a lack of customers for AI development firms, creating a demand-constrained market situation. The disparity between acquiring customers within national borders and internationally is another obstacle for Slovenian AI suppliers, whose domestic market is still underdeveloped. The inclination of clients to hire domestically stems from higher trust and lower risk of transferring their valuable data.

The need for hiring a highly skilled workforce in a time of very high and stable employment was, in the eyes of suppliers, the second most problematic area for growth (OECD, 2023). *"There is a total shortage of workforce on the market. You have to fight for talent person by person"* (AI-12). *"So currently staffing is the problem. But not just with us, with everybody. Because the economy is at its highest, the issue is present across the board: lack of highly skilled engineers and economists"* (AI-15). The latter was then also confirmed by others. *"Currently, in Slovenia, it is quite difficult to get new hires and, technologically, the things that we do are really advanced, and we are looking for more experienced people who quite often get even better positions working remotely for a big company from somewhere abroad"* (AI-16).

The development of AI is a capital-intensive industry with potential high value-added results. While this may not seem like a problem, it creates a significantly smaller market for AI solutions than it could otherwise be due to the high initial investment, which was most noticeable in the interviews with companies working on custom-delivered solutions, which tend to be more expensive to develop. *"Recently, we also had two smaller companies that are interested in AI solutions but do not have enough money for actual projects, and then we offered to do some consulting for them. So, there is still interest even on the smaller side, but the funds then typically present an obstacle"* (AI-14).

Lack of data was also among the main factors for customers not being able to implement AI solutions even where there was potential benefit and interest. *"The data is really hard to get because it is not captured in digital form. This a huge problem for a lot of industries striving to use AI despite what they say, they do not have data"* (AI-10). The issue was even more noticeable when discussing small and medium-sized companies. *"Success of AI solutions depends on the quality and quantity of the data"* (AI-13). *"Currently, I see the disadvantage, especially with our customers that do tasks very segmented, so not one person has all the knowledge about the problem. They do not have the whole picture because the structure of the company is so big and complex"* (AI-15).

The ability of suppliers to package their AI solutions into a product which can then be sold at scale is potentially the main difference between scalability and the growth or stagnation of a company. Companies providing solutions existing exclusively in the software sector without underlying physical products expressed struggles to find a product that could fit the market requirements. *"We have done that (AI as a product) once and had a bad experience. So, we tried to sell something to five different companies, and Slovenia is very small, and they said no, we do not want to have the same solution as the competitors and so on"* (AI-3). *"We did it (AI as a product), but it did not work. So, from the technological perspective, the product worked, but the business part of the product did not work right"* (AI-1). *"In these eight years, we did not find the right one (product) or maybe we just do not know how to start a new product. We do not have any product we can scale and sell"* (AI-14).

The relevant areas that affect the potential growth of AI suppliers in the region are summarised by a few key factors that are crucial to understand and remember. The biggest is the untapped market potential, which is partly attributed to the market still developing. Following is the lack of knowledge surrounding the topic, which also affects trust in the services. Close behind is the shortage of highly skilled workforce in the region, which is also being further depleted by large companies from abroad. AI is a data-driven and capital-intensive industry where training models require time and vast amounts of data; neither comes cheap when required to obtain on the market or internally. These factors result in high prices of AI-powered solutions. Data availability and quality is also a problem AI providers often encounter when developing new solutions. Finally, the lack of scalability in the industry since AI has to be adapted to each client's specific needs creates a problem for growth and prevents companies from being able to exploit economies of scale when developing new solutions and potentially decrease their pricing in the long run.

2.6 Policy and legislation

The proliferation of AI technology also attracted stricter regulation, with some companies encouraging it whilst others doubting its effectiveness. However, the majority agree that too strict regulation would suppress technological advancements and put the industry at a disadvantage. *"Policies should be designed with an open discussion with the academia, industry and all the relevant parties, not to end like the cookies policy"* (AI-14). The discrepancies between the economic regions would give some the upper hand and make others uncompetitive. *"I think it would be stupid if we let China just bypass us because we have self-regulated, and they have not"* (AI-9). Companies often suggested their field of operation is not the priority when it comes to limiting regulations. *"Legislation is far more crucial in the implementation of AI in the physical world and when dealing with personal data and not so much when dealing with business processes"* (AI-13).

However, this does not mean that legislation is redundant. *"There might be some need for legislation, maybe not so much about the AI models, but I would really like to touch upon the biases in the AI models and how to ensure that the data used to train the model is sourced properly"* (AI-16). *"Legislation and development need to go hand in hand, and limiting the development by the legislation is a step in the wrong direction"* (AI-17).

Others, in highly regulated fields such as medicine, have already experienced regulatory burdens in their development process. *"Right now, the model has to be locked. When it's locked, it must be validated, approved and you're not allowed to change the model afterwards. We work tightly with regulatory agencies like FDA, and we are working on new guidelines that would allow updating the model in a controlled setting"* (AI-6). *"It is a problem collaborating with Slovenia as the legislation is very strict, even stricter than Europe demands. To the point that it slows down the research. We can say that the legislation in Slovenia is kind of controlling and limiting our potential to utilise the data to advance the field of medicine"* (AI-6).

Companies, in general, agreed that the role of the government would be better suited to educating about the technologies rather than limiting its advancements. *"If the government would make sure that the general population and the companies are more knowledgeable regarding AI and what it has to offer, the acquisition of clients would be much easier for us"* (AI-14).

In addition to the legislative burdens, the potential taxation of AI technologies and the impacts this might have on the development were discussed, as well as long-term effects for the industry (Foley, 2023). When probing interviewees about the potential of AI taxation, they all responded that it would halt the development of the technology. *"Whenever you make some taxation or some regulation, you kind of attack the innovation in that field. I would advise them to think ten times, not just twice, before applying it"* (AI-1).

Rather than restricting the innovation, companies suggested more focus should be put on boosting it through various research-supporting grants, as it would bring greater returns in the long run. Combining the funding with the sandbox approach, where regulations would only apply to companies over a certain size, has been mentioned several times as a winning combination in encouraging innovation in start-ups and small companies for them to be able to compete on the global stage.

2.7 Funding

Companies typically apply for grants mainly in the beginning stages when they lack money and now only apply for projects that align with their vision to avoid losing focus. *"We are involved in these kinds of projects to be in touch with the state-of-the-art and get new perspectives. But on the other hand, you need to comply with the rules and be careful not to lose your best people on projects that are just projects per se"* (AI-2). *"It is often better just to apply for European money, not even Slovenian, because it is too much bureaucracy for the Slovenian one and too little money. You have to spend a lot of resources to do all the accounting, management and so on"* (AI-5).

Others expressed that interference in the innovation process is unnecessary as the free-market forces will allocate resources most efficiently. *"Start-ups move so fast that things become obsolete in the first year, not four years after you get those grants. I do not think these R&D grants are really meaningful. I think venture funding is much more relevant for start-ups because it is faster and more adaptive to the start-up innovation process"* (AI-9).

Offered incentives do not only encompass money, and some argued that Slovenia and the EU have an especially important role to play here. As the regulation gets stricter and more complex, especially smaller companies will need help with implementing and adjusting to new legislation. *"There are mechanisms in the start-up ecosystem that help, and it is not only about the money; it is also about the educationRight now, the model has to be locked. T now and the mentorships"* (AI-7).

It has been mentioned that the potential in the country is high and that there are role models to look up to. *"If we compare it to Israel, which is really top tier, I would say Slovenia missed out on some opportunities and should have been a deep tech country already two years ago"* (AI-8). Looking into the future, funding should be directed into supporting economically viable projects and not burden the companies too heavily with bureaucracy.

Table 2. Summary of key findings

Aspect of AI	Key findings
AI and its role	• Not limited to automation and can benefit vulnerable groups, such as the blind and visually impaired, by enabling tasks like reading digital information. • Seen as a problem-solving tool capable of addressing previously unsolvable challenges at a scale. • Becoming specialised, with companies focusing on specific verticals or niches. This shift favours smaller suppliers who can provide tailored solutions. • Despite uncertainties about its limits, AI is expected to have an increasingly significant impact on everyday life in the future.
AI supply market in Slovenia	• In Slovenia, only 12 percent of companies with more than ten employees use AI technologies. • Low adoption rate indicates untapped market opportunities. • Challenges when approaching international markets. • The cost can be a major obstacle, particularly for smaller companies. • Subscription-based models, per-product pricing, per-project pricing, or combinations of these are typically offered. • The problem for low AI implementation does not primarily lie with the supply side but with the clients' side, including affordability and understanding the value of AI solutions.
Customers and use cases for AI	• Companies use AI technologies to automate tasks, allowing employees to focus on creativity and exploring new business opportunities. • AI solutions must be personalised to meet the specific needs of clients and industries, and understanding those needs is a crucial competitive advantage. • Clients often lack prior knowledge of AI and require education about its functionality and benefits.
Obstacles to growth	• The AI development sector faces a demand constraint due to a lack of client knowledge and trust in new technologies. • Hiring highly skilled personnel is challenging due to a talent shortage in a time of high employment. • AI development requires significant capital investment. Custom-developed solutions can be particularly expensive for clients. • The lack of data, especially in digital form, is a common obstacle preventing clients from implementing AI solutions, particularly in small and medium-sized companies. • Suppliers face challenges in packaging their AI solutions into marketable products that can be sold at scale. The software-only sector struggles to find products that meet market requirements.
Regulation and policies	• The need for regulation varies depending on the field of operation. • Some companies advocate for legislation that addresses AI model biases and ensures proper data sourcing rather than restricting AI development. • Companies in highly regulated fields like medicine mention regulatory burdens and the challenges of updating AI models due to strict regulations, which can slow down research and development. • The government should focus more on educating the general population and companies rather than imposing strict regulations. • Potential taxation of AI technologies is commonly regarded as a step in the wrong direction, as it would impede technology development and innovation.
Funding	• Companies applied for grants primarily in their early stages when funding was scarce and now tend to apply for projects that closely align with their long-term vision to avoid losing focus. • Some argue that start-ups move too fast for traditional grants and prefer venture funding, which is more adaptive to the start-up innovation process. • Incentives for companies extend beyond monetary support, for example, education, mentorship, and support mechanisms for smaller companies to help adjust to new regulations. • Funding should be directed towards economically viable projects without burdening companies with excessive bureaucracy.

Source: Own work (2023).

Conclusion

The research showed that the supply side of the AI market in Slovenia is well-developed. The problem of low AI adoption lies in the hands of clients and governmental institutions due to the existing underdeveloped level of knowledge and digitalisation within companies. Lack of trust in this relatively new technology, high implementation cost, and a shortage of highly skilled workers in client companies hinder widespread AI adoption. The major challenges that, on the other side, inhibit the growth of Slovenian AI suppliers are, besides the shortage of a highly skilled workforce, the lack of recognition, and similar troubles accompanying the penetration of international markets.

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COGNITIVE TRANSFORMATION IN KOLEKTOR MOBILITY

Introduction

This chapter embarks on an exploration of AI-driven advancements in the automotive industry. The primary focus centres on the optimisation of manufacturing processes based on a case study of Kolektor Mobility, a prominent global player in specialised industrial production. Through this case study, the aim is to shed light on the transformative potential of AI in automotive manufacturing and understand how the integration of AI impacts productivity, sustainability, and competitiveness within Kolektor Mobility and its broader implications for the entire automotive industry.

Automotive industry manufacturers are in the process of a significant transition, facing challenges such as a labour force shortage in many developed countries and unprecedented shifts in supply chain dynamics, which have made it increasingly difficult for suppliers to the automotive industry to meet production demands (Rao & Verweij, 2017). Furthermore, the industry faces a dual transition: electric and autonomous vehicles are reshaping manufacturing, while more prominent players consolidate suppliers for a more resilient supply chain. The case explores how AI helps automotive manufacturers and suppliers overcome these obstacles while presenting an overview of AI's influence in the automotive sector, highlighting its capacity to optimise processes and adapt to global disruptions.

Zooming in on Slovenian manufacturing, the adoption of AI is analysed, with Kolektor Mobility serving as a standout example. This case study provides insights into the company's experiences and applications of AI in automotive manufacturing. Key findings obtained from the case study at Kolektor Mobility are summarised and project an outlook on the future of AI within the automotive manufacturing sector.

1 The use of AI in the automotive industry

Sectors such as automotive manufacturing that are very capital-intensive and are highly susceptible to automation in their operational processes will presumably see the biggest productivity gains from AI (Rao & Verweij, 2017). The advancements in AI technologies, coupled with the recent pandemic and geopolitical events, have expedited the incorporation of AI into various domains, rendering its applications more specialised (Rao & Verweij, 2017; Armutak & Fendri, 2022).

1.1 Unlocking the potential: Exemplifying AI's impact on the automotive industry

The COVID-19 pandemic severely disrupted global supply chains, which led to material scarcity and manufacturing process disruptions (Rao & Verweij, 2017; Armutak & Fendri, 2022). To deal with these challenges, the automotive industry turned to AI. Machine learning algorithms played a significant role in predicting and managing disruptions, optimising inventory and automating quality control processes. On the other hand, the Ukraine crisis impacted the automotive industry by triggering energy market instability, especially in Europe. This uncertainty put a focus on energy efficiency and sustainability in the automotive manufacturing companies. AI emerged as a key solution since AI-driven energy management systems can adapt to fluctuating energy prices and availability, helping companies to reduce costs (Makris et al., 2023). In addition, AI's advanced renewable energy technologies can effectively reduce environmental impact and integrate into hierarchical process models to achieve the company's KPIs. The biggest contribution of AI in the automotive industry is that it efficiently analyses large datasets and shows patterns and insights that are necessary for the processes (Makris et al., 2023). Its capabilities also extend to automating search processes, which allows employees to be allocated to other tasks.

While AI has been implemented throughout the critical parts of manufacturing in the automotive business, companies have put slightly more focus on adding AI solutions to their core production processes: product development, engineering, and quality (El-Jawhari et al., 2020). Smart modelling, digital twins, tool wear, and precise robotics are just some of the AI uses that propel enterprises to faster growth and more optimised processes (Makris et al., 2023). Implementing these, especially in automotive manufacturing, can be a game-changer. It is not just a technological shift but a strategic move that can optimise operations, reduce costs, improve product quality, and enhance decision-making capabilities. More specifically, a digital twin is a virtual replica of a physical system or process that can be used to simulate and optimise its performance by using real-time data from sensors and other sources. Creating shared models that describe manufacturing processes helps different parts of manufacturing operations work together more smoothly. It is like making sure everyone speaks the same language. Using standard file formats improves information flows between product, process, material and measurement models. It also makes it easier to use different engineering tools together, making the whole process simpler and more efficient (Makris et al., 2023).

ZF Friedrichshafen AG, a leading supplier to the automotive industry worldwide, has established its own technology centre for AI and expanded its partnership with Microsoft to establish one of the most comprehensive digital cloud platforms in the automotive industry (El-Jawhari et al., 2020). They are using AI to improve their end-of-line testing process in gearbox production. The testbench measures the gearbox's behaviour using different sensors, and AI-enabled assistance systems are used to support the decisions of testbench operators and rework personnel. Using AI significantly improved the efficiency of machine hours, working time, and material consumption, resulting in reduced costs and a better understanding of product failures.

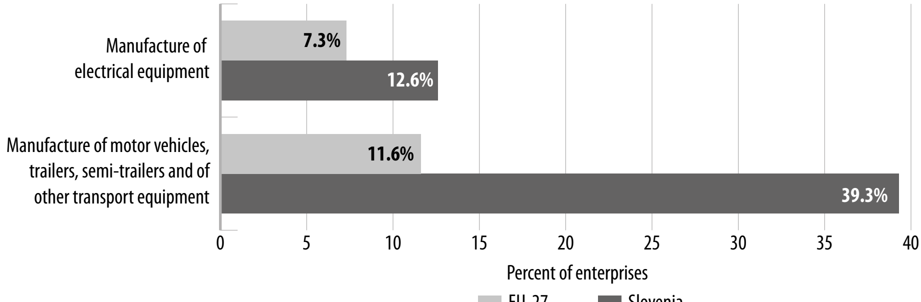
Companies that fail to adapt and adopt this fast-changing environment face the risk of quickly falling short and being undercut on turnaround times and higher costs (Rao & Verweij, 2023). One of the main challenges these companies face in terms of integrating AI into their business is the problem of a comprehensive digital transformation. AI does not reach its potential through partial solutions; it requires a fundamental change in the company's entire operational ecosystem (Makris et al., 2023), which means integrating existing systems, breaking down data silos, managing cultural shifts, and ensuring security and data privacy while still focusing on long-term sustainability and competitive advantage. Another challenge is the shortage of AI expertise, making it difficult for companies to develop and implement AI solutions. The digital maturity of the workforce is, therefore, a significant factor since the successful adoption of AI depends on employees' digital skills. Many companies also face technical barriers related to data management, integration and the quality of data. Lastly, the upfront costs of AI implementation are usually substantial, and companies have to allocate resources for AI infrastructure, software and employees. In addition to upfront costs, there is uncertainty about AI solutions' return on investment (ROI). Predicting the exact financial benefits can be challenging, and ROI may not materialise as quickly as anticipated. This uncertainty can make decision-makers cautious and lead to delays in AI adoption. However, the ROI for AI in this industry is positive, and the payback period should be tangible in one to two years for these investments (Armutak & Fendri, 2022).

1.2 Use of AI in Slovenia and the EU

Implementing AI in manufacturing (C sector) is well underway in Slovenia. The primary emphasis of this research lies within the realms of C27 (manufacture of electrical equipment) and C29 (manufacture of motor vehicles), aligning with Kolektor Mobility's operations, which integrate into these two industry categories.

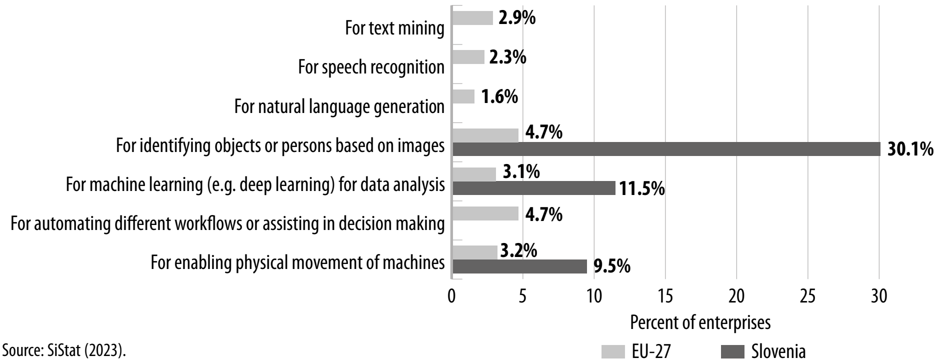
In the manufacturing sector, Slovenian companies with ten or more employees have embraced AI technology at a rate of 12.6 percent, as depicted in Figure 1 (Eurostat, 2022). In contrast, the adoption rate in the European Union (EU-27) stands at a lower 7.3 percent. Likewise, in the motor vehicle manufacturing sector (C29), the EU-27 demonstrates an 11.6 percent adoption rate, while Slovenia showcases a substantially higher rate of 39.3 percent. These statistics suggest that Slovenia has more extensively integrated AI technology into these industries compared to the EU-27, indicating a potentially more advanced adoption of AI in Slovenia.

Figure 1. Percentage of enterprises with at least one AI technology use in their sectors in 2021



Source: Eurostat (2023).

Figure 2. Percentage of AI types used in the manufacture of motor vehicles (C29) in 2021

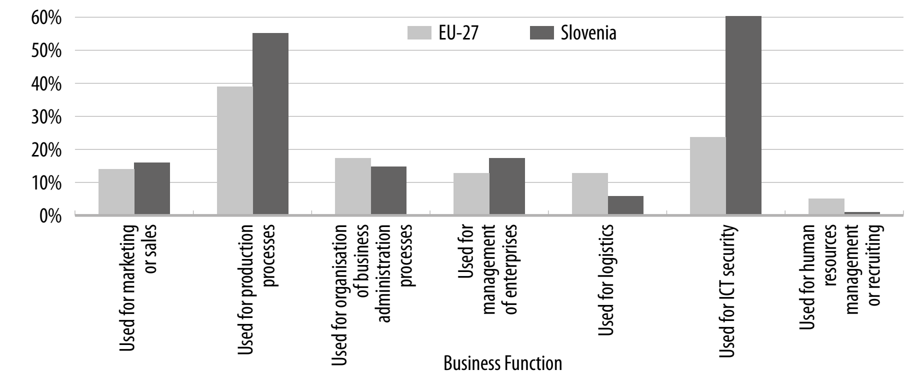


Source: SiStat (2023).

Most Slovenian manufacturing companies incorporate AI technology for tasks like recognising objects or people in images (Figure 2). The companies primarily use computer and machine vision applications, which play a significant role in quality control during the manufacturing process. Natural language generation, speech recognition and text mining are much better utilised in Europe than in Slovenia, where it is basically non-existent.

The only notable difference in use by business functions is that the share of companies using AI for ICT security purposes in Europe is three times lower than in Slovenia (Figure 2). On the other hand, other European countries outperformed Slovenia in using AI for logistics and human resource management. In these areas, AI adoption is more widespread across the broader European landscape.

Figure 3. Use of AI across different business functions in the manufacture of electrical equipment (C27) that use AI in 2021 by percent



Source: SiStat (2021).

2 AI in Kolektor Mobility

Kolektor Mobility is a multinational corporation based in Slovenia with an extensive network of companies and subsidiaries across Europe and Asia, operating in the field of highly specialised industrial production (Kolektor, 2023). They specialise in high-tech manufacturing within global niches of electromechanical components and electric drives for mobility and industry needs. In 2022, the company had 3,304 employees; of these, 1,637 were employed by groups in Slovenia and 1,667 by groups abroad (Table 1). Sales revenues were €403.7 million, resulting in a net profit for the financial year of €16 million (Kolektor, 2023).

Table 1. Key financial data for Kolektor Mobility and the industry

In EUR	Kolektor Mobility	Industry, NACE code C29
Revenues from sales	403,658,000	3,151,977,060
Number of employees	3,304	25,134
Sales per employee	122,173	125,278
Added value per employee	46,000	46,800

Source: AJPES (2022), SiStat (2022) and Kolektor (2023).

In 2022, Kolektor Mobility had a total of 14 manufacturing companies or locations in eight countries worldwide, with two locations in the process of discontinuation. These production companies operate within four programmes (Kolektor, 2023). The optimisation of production continued at the best manufacturing locations. The Slovenian share of the company's manufacturing activities includes five companies: Kolektor Sikom d.o.o., Kolektor ATP d.o.o., Kolektor Orodjarna d.o.o., Kolektor Ascom d.o.o., all with a 100 percent ownership share, and Kolektor KFH d.o.o. with a 33.33 percent ownership share (Kolektor, 2023).

Despite the improvements in equipment manufacturing efficiency during the last years, there was an observed decline in overall equipment efficiency due to the dynamics in the business environment (Kolektor, 2023). The decline was primarily attributed to prolonged delivery times and the escalating costs of components and parts. In response to these challenges, Kolektor Mobility initiated the integration of the Qlector LEAP AI platform for production guiding into its manufacturing processes (Qlector, 2023). This platform, developed by Qlector — a portfolio company of Kolektor, closely affiliated with the research community, notably the Artificial Intelligence Laboratory at the Jožef Stefan Institute — utilises artificial intelligence to assists discrete and process manufacturers facing challenges related to transparency gaps, suboptimal resource utilization, and tacit knowledge capture, enabling them to enhance their operational excellence and productivity through the utilization of a data-driven cognitive digital twin.. The implementation of this platform was strategically introduced across all relevant facilities within the organisation (Kolektor, 2023).

To gain a comprehensive understanding of AI utilisation within Kolektor Mobility, two in-depth interviews were conducted in August and September 2023, one online with the President of the Board of Management of Kolektor and the other in person with Kolektor's digital engineering manager. During the in-person interviews, we visited Kolektor's facility in Idrija, where we observed the operation of AI technologies and advanced robotic systems. Interview questions were crafted to delve into key aspects of AI implementation, encompassing short-term and long-term objectives, the advantages and challenges faced, the impact on organisational transformation, data management and security measures.

Kolektor Mobility uses various types of AI that can be grouped into four major areas. The first type is data-driven AI, which includes machine learning, neural networks, artificial general intelligence, predictive analytics, data analysis, process optimisation and quality control. The second type is social robotic and physical automation AI, which includes digital twins, KoCo robots (a project made in collaboration with Airnamics), simulation, and augmented reality. They also use natural language processing, which includes large language models and finally, the last type, which provides cognitive assistance and decision support.

2.1 Motives and implementation of AI

In the ever-evolving landscape of the automotive industry, the imperative for manufacturing companies to incorporate AI into their solutions has never been more compelling. With the seismic shift towards electric vehicles reshaping the entire automotive business model, the company recognised early on that digitalisation presented a transformative opportunity to not only adapt but thrive in this new era. The President said: *"Kolektor knew in the early beginning that digitalisation is an opportunity, as a new business model, to expand our offering on the market, as well as making ourselves better, more competitive."*

Their primary motive lies in the pursuit of automation, aiming to liberate both physical labour and mental efforts. By harnessing AI-driven technologies, they seek to achieve precision and efficiency, realising substantial savings in time and resources in high-volume production while minimising disturbances. This commitment to innovation underscores their dedication to staying at the forefront of automotive manufacturing, aligning their goals with the changing tides of the industry, and ensuring a sustainable future.

The implementation of AI processes within the company followed a meticulously structured approach. It all began with a clear vision and well-defined goals, which formed the foundation for their overarching strategy. To understand the current state, they sought the expertise of the Faculty of Computer and Information Science, enabling them to assess their strengths and areas needing improvement. The next crucial step involved recruiting highly skilled professionals who could help them realise ambitious plans, culminating in the establishment of an innovation centre. Their primary focus has been integrating cognitive assistance throughout managerial, business, and support processes. Central to this endeavour was robust data collection and analysis to drive informed decision-making, or as the President of the board put it: *"This is no longer planning but basically leading the manufacturing, meaning the system of orders, based on historical data we collect. Live data is collected through sensors, and given the situation based on the algorithms, we decide the best option for the manufacturing at the time."*

Kolektor Mobility recognised the importance of aligning AI-driven processes with the specific context of the organisation, products, and existing workflows. The digital transformation journey was divided into three phases: the mental transformation of the workforce, digitising unautomated processes, and full-scale automation. Ensuring compliance with regulations became paramount, leading to the development of a specialised protocol management system.

Amongst the various AI implementations, robotics proved to be the most intricate and time-consuming, an ongoing project that continues to evolve. The head of digital engineering expressed the following regarding the deployment of advanced robotics: *"We are still developing (robotics), and we are still finding new ways to use all the algorithms, all the cameras and so on. It is constantly under development. We see more and more things that can be done. How to work in autonomous ways."* Through this comprehensive approach, they have not only embraced the potential of AI but have also laid a solid foundation for sustainable growth and innovation in the automotive manufacturing industry.

2.2 Benefits and challenges

In Kolektor Mobility, AI's impact on the business model is evident. While specific short-term and long-term goals are still in development, Kolektor already operates several hundred robots, with 12 AI-leveraged agile robots boasting an exceptional 45 percent return on investment, far surpassing the industry average of 10 to 15 percent. The main advantage lies in their agility, contrasted with traditional robots that require frequent mechanical adjustments and are limited to predefined operations. Agile robots, utilising sensing and adaptation, seamlessly integrate new products and maintain production efficiency without disruptions, unlike their predecessors that often ran incessantly due to constant fine-tuning. *"And that is where we gain the difference, I would say - in terms of robustness. This system works without the need for additional support personnel. Previously, with traditional robotics, we needed people to maintain them. The more robots you have, the more maintenance personnel you need. That is where we achieve savings"* (President of the board).

Initiatives such as Enterprise Resource Planning (ERP) system integration and Robotic Process Automation (RPA) exemplify their commitment to a well-coordinated, technology-driven approach. Implementing virtual robots, for instance, eliminates the need for manual data entry, allowing for 24/7 automated operations, thereby optimising workforce productivity.

"Those who have services, like a machine here, need a person for planning or invoicing. Now, we introduce a virtual robot, and a person is no longer needed to input invoices; the robot does it all day, not just from 8 a.m. to 4 p.m. That is how we are approaching it" (President of the board).

Furthermore, using AI-driven big data analysis within Kolektor translates to significant productivity and product quality gains. By scrutinising data, conducting in-depth analyses, and optimising processes with digital twins, they achieve quicker robot calibration, enable a single robot to handle multiple product variations with minimal switching time, and ensure workers' tasks are executed accurately. This data-driven approach forms the cornerstone of their strategic planning, enhancing overall operational efficiency.

Regarding broader regional impact, Kolektor anticipates significant influence within Slovenia and potentially in Central Europe, particularly due to their active engagement in green mobility and digital transformation. Their pioneering efforts, once visionary, have now become tangible through the smart factory platform and industry-wide recognition, fostering innovation and leaving a lasting mark in their respective fields.

AI implementation is also full of challenges. One of the primary challenges faced by the company was the need to integrate robots quickly and enable them to adapt rapidly from one process to another. It posed a significant challenge because traditional methods, such as sensor-based or standard programming, were insufficient for achieving this level of agility. Instead, the solution relied on 3D scanning and complex algorithms to coordinate the robot's actions within the coordination system. *"If we were not able to do this by sensor, by standard programming, it was only possible by the 3D scanning and the algorithms in the back which told us how to coordinate the robot to do the task in the coordination system"* (Head of digital engineering).

To address this challenge, Kolektor Mobility implemented a Robot Operating System, which allowed them to combine various robots and algorithms seamlessly. Additionally, the concept of a digital twin of the robot was introduced, enabling real-time monitoring of its movements and automatic corrections to ensure it followed the correct path, especially from a safety perspective.

Another challenge lies in articulating the specific requirements for the robots. Kolektor Mobility had to communicate its vision to suppliers, emphasising the need for robots capable of switching between products in just 15 minutes. Besides technical challenges, convincing leadership to invest in AI and automation requires a belief in the technology's potential and a willingness to commit resources and funding. *"If you do not believe that you can actually automate things, then you will not embark on this path. You have to believe in it"* (President of the board). Given the uniqueness of each context, the uncertainty of AI's success added to the challenge.

Additionally, there were legislative and regulatory challenges related to AI implementation. General Data Protection Regulation (GDPR) was mentioned as a limitation, particularly when using cameras as robot sensors. Compliance with privacy standards was essential, including measures like blurring or not storing images captured by robots. Addressing the ethical aspects of AI and automation was also a special concern. Kolektor Mobility approached this through open communication, explaining the goals, impacts, and adherence to ethical standards to all stakeholders. This communication extended to employees and their representatives, including unions. *"I cannot imagine using any tool or law in such cases. I think communication is necessary"* (President of the board).

The goal was to emphasise that AI and automation aimed to benefit employees by reducing physical workloads, improving job quality, and increasing satisfaction. In some cases, involving sociologists or psychologists helped in softening potential conflicts. This open and transparent communication aimed to align various perspectives and ensure a smoother transition to AI-driven processes within the company.

Conclusion

Kolektor Mobility's primary motive for integrating AI is to achieve automation, enhance efficiency, and foster agility, aligning with the changing landscape of the automotive industry. Their implementation strategy is well-structured, beginning with a clear vision and involving the recruitment of skilled professionals and the establishment of an innovation centre. Implementing AI in Kolektor Mobility increased the reliability and efficiency of robots, improved data-driven decision-making and consequently optimised productivity, improved quality and reliability, and saved costs.

Despite the successes, Kolektor Mobility faces challenges in quickly integrating and adapting robots, articulating specific requirements to suppliers, convincing leadership to invest in AI, addressing legislative and regulatory issues and managing ethical concerns. They approach these challenges through technical solutions, open communication and transparency with all stakeholders. Overall, Kolektor's adoption of AI has positioned them as innovators in the automotive manufacturing industry, with tangible benefits in terms of efficiency, productivity and broader regional impact.

Regarding broader regional impact, Kolektor anticipates significant influence within Slovenia and potentially in Central Europe, particularly due to their active engagement in green mobility and digital transformation. *"I dare say we might be bold enough to claim some influence in Central Europe. In Slovenia, however, we will certainly have a big impact"* (President of the board). Their pioneering efforts, once visionary, have now become tangible through the smart factory platform and industry-wide recognition, fostering innovation and leaving a lasting mark in their respective fields.

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REVOLUTIONISING TELECOMMUNICATIONS: THE ROLE OF AI AT TELEKOM SLOVENIJE

Introduction

The telecommunications industry is undergoing a transformative shift with the integration of AI into its core operations. Its role in enhancing customer service is substantial, with chatbots simplifying routine inquiries and AI language models similar to GPT-3 providing context-aware responses (Deotale, 2023). Additionally, AI plays a vital role in personalised advertising, enhancing customer engagement and minimising customer turnover. Telecom companies leverage AI for network optimisation, identifying and resolving real-time issues. Predictive maintenance ensures network reliability, while AI aids in fraud detection and prevention.

This chapter aims to examine the various implications of AI in the telecommunications industry, how the adoption impacts it, and gain insight into how one of the most prominent players in Slovenia is contributing to the transformation based on empirical evidence.

The chapter comprises three sections. Firstly, it provides an overview of the ICT sector and, more precisely, telecommunications, explaining the industry specifics in Slovenia and the EU. The research delves into the different ways the telecommunications industry is adopting AI-based technologies and how AI is helping transform it. Afterwards, the focus is put on Slovenia's leading player in the industry, Telekom Slovenije. Lastly, the empirical part provides insight into how Telekom Slovenije is navigating the transformation of AI adoption and integration, focusing on customer satisfaction and promising pilot projects in logistics.

1 The use of AI in telecommunications

According to the NACE classification, telecommunications belong to the service ICT sector, the largest contributor to net turnover and value-added, at 89 percent, in the entire Slovenian ICT sector in 2021. Within this sector, 37 percent was in J62 – Computer programming, consultancy, and related activities, and 33 percent in Telecommunications (SORS, 2022).

In the ICT sector, by integrating all the listed uses of AI technology in Table 1, Slovenia is notably ahead of the EU average in all listed categories. The biggest differences are seen in the use of AI technologies for marketing and sales, ICT security reasons, and management of enterprises, at 26.1, 27.6, and 14 percent, respectively. Other uses for AI technologies include production processes, organisation of business administration processes, HR, and recruiting. The largest deployment of AI technology in the telecommunications sector in the EU is for marketing or sales and ICT security. The most significant difference between activities in Computer programming, consultancy, and related activities and Telecommunications in the EU is its use for marketing and sales, it being more widely used in the latter. AI technology in Slovenia and the EU is used most for ICT security (Eurostat, 2023).

AI technologies used in enterprises were in the largest share developed by employees across the board, 82.7 percent of ICT enterprises in Slovenia and 56.6 percent in the EU. As for EU telecommunications enterprises, 42.1 percent developed their own. In other cases, enterprises used commercial or open-source software and modified them on their own. Compared to the entire ICT sector, the EU telecommunications sector was more inclined towards ready-to-use commercial software or externally developed and modified technologies (Eurostat, 2023).

In recent decades, the telecommunications industry has seen major technological growth due to a growing demand for data services (Tapia et al., 2018). This expansion also brought challenges, like telecom fraud, impacting operators and consumers (Deotale, 2023). Automated solutions are being explored to maintain radio tower operations (Liul, 2022). Operators aim to differentiate themselves by improving user experiences to meet rising customer expectations (Tapia et al., 2018). Call centres in the telecommunications businesses are frequently overburdened by repetitive demands, resulting in high wait times and ineffective customer service (Deotale, 2023).

Table 1. AI technologies usage for various purposes by sector in 2021, in percentage of enterprises

Activities	Telecommunications		Computer programming, consultancy, and information service activities		Information and Communication Technology - Total	
Area	**EU**	**Slovenia**	**EU**	**Slovenia**	**EU**	**Slovenia**
Enterprises use AI technologies for marketing or sales	41.6	NA	30.2	58.5	30.0	56.1
Enterprises use AI technologies for production processes	27.5	NA	23.3	17.2	22.8	21.3
Enterprises use AI technologies for the organisation of business administration processes	24.7	NA	26.1	29.9	25.6	28.2
Enterprises use AI technologies for the management of enterprises	20.4	NA	20.6	41.5	20.9	34.9
Enterprises use AI technologies for logistics	7.2	NA	7.3	5.4	7.4	9.5
Enterprises use AI technologies for ICT security	36.5	NA	33.5	64.1	33.6	61.2
Enterprises use AI technologies for human resources management or recruiting	NA	NA	10.9	16.7	10.3	16.3

Notes: EU - 27 coountries of European Union; NA – not available

Source: Eurostat (2023).

1.1 Various applications of AI in the telecommunication industry

AI's integration into the telecommunications industry offers a smart solution to cut operational costs by reducing the need for constant human involvement in network setup and maintenance. Additionally, automation reduces the client onboarding process and speeds up the launch of new services (BlueWeave, 2023). In 2023, 60 percent of telecom firms expect AI to enhance operations, with IBM, Microsoft, and others already using machine learning, deep learning, and natural language processing (Liul, 2022). Moreover, AI adoption was well underway in 2021, with 19.9 percent of EU telecoms integrating at least one AI technology into their operations (Eurostat, 2023).

Furthermore, AI's transformative impact extends to various aspects of the telecom industry, including customer satisfaction. Exceptional customer service often relies on AI, like chatbots (Liul, 2022). AI filters and manages simple inquiries, leaving complex ones to humans. In the past year, 88 percent of customers interacted with chatbots, and 62 percent preferred to wait for a human. AI tools like Copilot and language models like GPT-3 improve telecom customer service with contextual responses and interactive chat experiences (Deotale, 2023). Another great example of AI utilisation was at Telefónica during the pandemic. To ensure quick help to customers over the age of 65, they initially asked customers about their age, but this led to inaccuracies due to dishonesty. They quickly adopted Nuance's Gatekeeper, utilising voice biometrics to identify seniors with over 95 percent accuracy (Nuance Communications, 2022). Lastly, AI elevates advertising and marketing with personalisation. It segments customers, tailors campaigns, offers recommendations and boosts engagement. Analysing data uncovers pricing and cross-selling opportunities, driving revenue. AI-driven churn prediction increases retention and reduces acquisition costs (Gour, 2023).

Beyond customer service and marketing, AI is vital to network optimisation. AI enables telecommunication companies the potential to enhance network optimisation through the automated adjustment of network configurations, resulting in improved performance and cost reduction. AI algorithms can be utilised for extensive data analysis generated by telecommunication networks, yielding valuable insights into network performance and facilitating the real-time identification and resolution of issues (Deotale, 2023). For example, during network downtime, AI-powered systems can restart cell sites. Algorithms can be pointed out as parts of the network with a high number of customers that would benefit from improvements, leading to higher profits (Sadekov, 2022). Due to 5G deployment, network complexity is set to exponentially increase over the next five years by 73 percent in size, more than five times the rate observed in the preceding five years (Deotale, 2023).

Speaking of network performance, AI not only optimises it but also plays a pivotal role in predictive maintenance, ensuring networks remain robust and reliable. AI is capable of identifying and mitigating potential faults before they occur. Predictive maintenance tools analyse data from telecommunications networks to identify patterns that may signal an impending failure or disruption. This proactive approach minimises network downtime and enhances overall network reliability, contributing significantly to operational efficiency (Onpassive, 2023). Only a few years ago, field workers were performing checkups on network equipment, resulting in errors and delays, which can now be reduced or even avoided (Sadekov, 2022). Ericsson has reported that implementing AI solutions in networks can lead to an up to 60 percent decrease in network performance issues and a 35 percent reduction in critical incidents. Moreover, a 15 percent reduction in costs was recorded through automation, making the network more sustainable (Aydogmus & Mattsson, 2022).

Finally, AI addresses a pressing concern in the telecommunications industry: fraud detection and prevention. Telecommunications fraud poses a significant risk and a pain point to operators and consumers. In 2021, it led to a 2.22 percent in total global telecom revenue loss, according to the Communications Fraud Control Association (CFCA, 2021). AI algorithms can analyse vast amounts of data and aid in fraud detection and prevention in real time. Usually, algorithms analyse patterns and identify any irregularities that may indicate fraud. Practical examples include detecting and preventing SIM swapping, unauthorised network access, and bill fraud (Deotale, 2023).

1.2 Challenges and the future of AI adoption

Considering the profound transformation AI can bring to the telecommunications sector, it is essential to acknowledge the hurdles that have slowed its adoption. Telecom companies have encountered various challenges on this journey. These include a scarcity of skilled professionals and resources, the overwhelming quantity and unstructured nature of data, and the complexity of integrating AI with existing systems. Security concerns loom large alongside stringent regulations and data privacy requirements, especially in the EU, where GDPR mandates transparency in data use and protection (Amimer, 2022).

Despite these challenges, the future of AI adoption in the telecommunications industry appears exceptionally promising. Projections indicate a remarkable 40.25 percent compound annual growth rate for the global AI market within this sector between 2023 and 2029 (BlueWeave, 2023). While the industry is still in the early stages of its AI adoption journey, key players are making substantial investments in AI, primarily focusing on enhancing network operations and optimising the customer experience (NVIDIA, 2023). This investment sets the stage for a transformative future where AI will likely play an increasingly central role in telecommunications.

2 About Telekom Slovenije

Telekom Slovenije is Slovenia's leading and most technologically advanced provider of ICT (Information and Communication Technology) services and solutions. It was founded in 1991 as Mobitel and later merged with Telekom Slovenije to establish the Telekom Slovenije group as it is known now. Their company activities include 'fixed and mobile communications and ICT solutions', 'digital and multimedia content and services', 'development and implementation of business content management solutions and tools for management and monitoring of business', 'cybersecurity and Internet of Things (IoT)', 'construction and maintenance of telecommunication networks', and other services such as financial services, solutions for e-health, insurance, smart home, cities, communities, industry, and e-mobility. The majority of Telekom Slovenije is state-owned, with 62.54 percent owned by the Republic of Slovenia (Telekom Slovenije, 2023).

Telekom Slovenije holds a majority share in many different companies such as GVO, Aventa, TSmedia, SOLINE, TSinpo, and IPKO Telecommunications (all Ltd.). The company operates not only in Slovenia but is also very prominent in Southeastern Europe. It operates in Croatia, Serbia, Montenegro, Bosnia and Herzegovina, Kosovo, and North Macedonia through its subsidiaries owned 100 percent by Telekom Slovenije. They also own several trademarks/brand names, the biggest being Telekom Slovenije, NEO (platform for smart living), IZI (Pre-paid services), and VALU (smart wallet) (Telekom Slovenije, 2023).

Their main focus is to inspire their users and partnering companies with innovative technologies and help open up new business and personal paths by being open, flexible, and always upgrading their products and services (Telekom Slovenije, 2023).

Table 2. Selected data about Telekom Slovenije and applicable industry per year

Categories	Telekom Slovenije	Industry, NACE code 61100
Revenues	612,166,818	1,422,550,000
Average number of employees based on hours worked during the accounting period	2,033	5,306
Revenues per employee, in EUR	300,969	268,102
Added value per employee, in EUR	130,685	95,872

Source: AJPES (2023).

As shown in Table 2, Telekom Slovenije accounts for almost half of the industry's revenues, with higher revenue and added value per employee than the industry average. It also employs about 38 percent of the industry's workforce. The total number of employees in the Telekom Slovenije Group is 3,262. Within this number, 32.7 percent of employees are women, while the other 67.3 are men. They had revenues of EUR 652 million in 2022, a 1 percent increase from the previous year. The net profits for 2022 were EUR 37.5 million, which decreased by 1 percent from the previous year. ROE (return on equity) was 6.2 percent in 2022. The company holds the largest market share in three out of the five most important segments: internet protocol television (40.7 percent), mobile communication/telephony (35.5 percent), and mobile internet/data (30 percent), and in the other segments, such as IP Telephony (32 percent) and fixed broadband (27.3 percent), the company is in second place (Telekom Slovenije, 2022).

In its 2022 annual report, Telekom Slovenije noted that Slovenian customers quickly embrace and adapt to new technologies, including artificial intelligence (AI), as a significant recent behavioural shift. (Telekom Slovenije, 2023). In 2018, the company introduced the TV platform NEO to the Slovenian market, where they use AI in their voice-activated search on their remote controls. Since launching, over 120,000 users of Telekom's services have used the voice search feature of NEO (Finance, 2023). The firm also wants to implement artificial intelligence in its other services moving forward because Telekom Slovenije recognises the trends and is investing in that direction (UporabnaStran, 2023).

3 Empirical analysis of the use of AI and new technologies in Telekom Slovenije

3.1 Research methodology

The qualitative research is based on in-depth interviews with representatives from different fields of expertise (Table 3) within Telekom Slovenije. The core objective of this research was to gain a profound understanding of the inner workings of an ICT company, with a particular emphasis on revealing the advantages and challenges associated with the implementation of AI.

Through conducting interviews, the focus was on three fundamental technological areas within Telekom: Internet of Things (IoT), 5G technology, and artificial intelligence (AI), with a particular emphasis on the implementation of AI in voice recognition. Moreover, the interviews provided insight into topics related to knowledge exchange among employees, project planning, and the company's future goals.

Table 3. Sample characteristics

Interviewee	Interviewee's position(s)	Interviewee's gender	Interviewee's tenure
TS-1	Director of Technology Development	Male	Three years and ten months
TS-2	Voice control coordinator	Male	Two years and four months
TS-3	Head of Research and Development	Male	Four years and seven months
TS-4	CEO	Male	One year

source: Own work (2023).

3.2. AI transformation in the telecommunications industry

"Telecommunication companies dive into a new technology approximately every ten years" in the rapidly evolving ICT industry, necessitating a constant pursuit of competitiveness. *"If we lose the competitive advantage that we have, we will not be able to compete on price, which means that we will have to reduce prices, which means that our ARPU will fall"* (TS-1). Moreover, *"Every new technology has met with some resistance," which is why the users must be "willing to embrace and trust some new technology, which is not so simple to achieve"* (TS-3). To avoid the slower adoption of new technologies due to public perception, *"it is very important to talk about facts, we can observe the example of 5G, its "danger" is no longer the prevailing perception. (...). Here we see that only through quality dialogue, the public perception gets in the right place. The same will go for artificial intelligence"* (TS-4). When presenting something new, it is essential to catch *"the "hype" phase because when you put the new technology on the market, it is gone. Only when the technology matures"* (TS-1) do the clients start to use and adopt it willingly.

Despite potential uncertainties in client demand and company investments, these companies must prioritise new technology development to retain customers accordingly. The fundamental goal for the industry is *"improving the user experience and tailoring solutions to users, since until now, we have tried to be as general as possible in our offer, and now we are trying to personalise it as much as possible"* (TS-4). Telekom maintains an advantage because they *"are big and have accumulated a lot of experience that makes it easier to access customers," all while "constantly upgrading the network and adding new* *base stations"* (TS-1). Besides staying updated with technology, the significant challenges in the ICT industry include making substantial investments and acquiring essential knowledge for further technological progress. In pursuit of a viable solution, Telekom acknowledges that *"working on scholarship holders and education of young good staff"* (TS-1) represents a significant step in the right direction. Furthermore, Telekom collaborates with universities, as they recognise that *"universities are moving forward with technology"* (TS-1). Projects are carefully selected with an *"emphasis on projects with the greatest market potential"* (TS-3). Collaboration with universities and other partners not only assists in attracting young talent but also guarantees a commitment to ongoing research. To remain current with emerging trends and developments, ensuring effective communication and the seamless flow of knowledge within the company is imperative. *"Internal training is well organised at Telekom. The presentation of some new technologies is streamed online to everyone in the company who wants to hear it, or they can also attend it in person."* This approach to training allows them to be the leader in the ICT market in Slovenia. *"If you do not provide constant training, the staff and, consequently, the company will stagnate"* (TS-1). Additionally, another focus of a new role of AI in their company is through *"automatisation of routine tasks, specifically in network management and maintenance"* (TS-4). By removing tedious routine tasks, *"processes will be more efficient, human work will restructure to make decisions for the machines. Our goal is to keep decisions in the hands of humans and have AI perform the supporting tasks"* (TS-4).

Table 4. Key findings of Telekom Slovenije

Subchapters	Key findings
Adoption of 5G network	• 5G is crucial, offering improved speed, reliability, and safety. • Telekom Slovenije advances 5G, including private networks. • Transitioning from pilot projects to customer implementations in the near future.
Adaptation to AI in cybersecurity	• AI expands cybersecurity to protect valuable data. • AI is vital against autonomous bot attacks. • Telekom's AI-human approach strengthens security.
AI-powered voice recognition engine (NEO)	• NEO outperforms previous solutions developed through collaboration and AI model adaptation. • Improves user experiences and accessibility. • Addresses customer needs effectively.
Future of AI applications	• Exploring AI applications in customer service, chatbots, and text-to-speech synthesis. • Predictive maintenance and network optimisation hold promise. • Leveraging AI for efficiency and customer satisfaction.

Source: Own work (2023).

Telekom has *"three main focuses in development – 5G and related services, IoT, and artificial intelligence. These are more advanced technologies"* (TS-1). In this chapter, the primary focus is on artificial intelligence, with a particular emphasis on its intersection with 5G technology, which plays a pivotal role in shaping AI technology applications in the telecommunications industry. Furthermore, their fundamental role in cybersecurity critical infrastructure ensures the safety and privacy of customer data alongside their cutting-edge telecommunication services. Table 4 summarises key findings, which are presented in detail later on.

3.3 Adoption of 5G network

"As for the field of communication, of course, the main hit is the 5G area" (TS-1), indicating the importance of the 5G network which Telekom Slovenije has been offering since June 2021. Telekom Slovenije currently has a coverage of over 40 percent of the population with its 5G networks. This type of network addresses the industry with all critical features, such as speed, reliability, and safety features. While 5G may not appear drastically different from earlier technologies like LTE, Telekom is actively advancing its 5G capabilities, including the development of private 5G networks for large enterprises, referred to as '5G campuses'. These private networks offer superior service quality and enhanced data security by routing all company data through a dedicated network. While private networks have not been fully deployed or monetised, the company is already in the pilot project phase. *"Luka Koper set up a private 5G network"* (TS-1), talking about their first 5G campus pilot project, which began in 2020, when Telekom set up the first private 5G network to explore possibilities for process optimisation, logistics management, increased efficiency in the firm and lowering environmental impacts. While Luka Koper mainly currently mainly uses the Wi-Fi network, it plans to replace it with 5G in the future. These new networks are not yet being monetised, but the company is already looking for customers. *"We talk to customers specifically; we already have offers on the table. In certain cases, we are also towards the end of negotiations, so to speak"* (TS-1), which might suggest that Telekom may soon transition from pilot projects to implementing paid customer projects.

It is important to consider the benefits of a mobile 5G network compared to Wi-Fi. *"Reliability is definitely on the side of 5G"* (TS-3) since a Wi-Fi connection can get interrupted several times a day. 5G offers better coverage with just one base station, unlike Wi-Fi, which needs nearby access points. Clients could even use 5G to create a Wi-Fi network by using an internal 5G modem that turns external 5G into Wi-Fi.

3.4 Adaptation to AI in cybersecurity

In the ICT industry, companies are increasingly providing a broader range of services related to cybersecurity. Good cybersecurity *"was originally an internal need and has increasingly evolved to a service for external needs"* (TS-4). Companies recognise that data is one of the most valuable assets and strive to protect it to the best of their abilities. As the largest operator, Telekom has a natural role in ensuring security. *"This is not a very high cost, looking from a financial point of view, but it is a risk that is very a fundamental, real business risk"* (TS-4). The risk increases with new technology, and companies need a centralised response. *"If a centralised response is needed, it requires a centre, knowledge, infrastructure and experience. Experience is a big part of this, and it is difficult to replicate"* (TS-4). Therefore, Telekom has a cybersecurity centre, where they *"have a team of people who are constantly checking all the traffic 24/7 via various devices, what goes in and what goes out, for us and our customers. In case of any hitches, we help and analyse"* (TS-1). In today's world, a growing number of cyberattacks are aimed at companies and even more so at individuals. A lot of them are purely done by autonomous bots, making it very hard to determine the purpose of the attack. *"This is a significant problem, especially when bots become autonomous and self-generating. It requires a better quality of response than in the past. You cannot respond to it except with artificial intelligence because autonomous bots are artificial intelligence"* (TS-4). To tackle and overcome this challenge, the optimal approach is to leverage AI, as it possesses the unique ability to discover insights and patterns beyond the scope of human perception and understanding. Telekom is working with a combination of tools that incorporate both AI-driven analysis and human insight, enabling them to discern correlations and digital traces within global events. This integrated approach strengthens their cybersecurity infrastructure even further. To provide a safe service, in Telekom, they *"are thinking ahead, what are the things we can improve and where else we can contribute"* (TS-4).

3.5 AI-powered voice recognition engine – NEO

In Telekom, the idea of a voice control engine started long ago. *"We first met with AI technology three or four years ago while developing the new NEO platform. At that time, we set ourselves the goal of making the most advanced thing that exists on the market, what the competition has both in Slovenia and abroad"* (TS1). AI-supported voice recognition was a desired feature for NEO's December 2018 production launch. Initially, a paid solution, specifically Google voice recognition, was employed because *"there are not that many people in Slovenia, and it is difficult to gather a learning crowd to develop our own model. It was the best option at the time"* (TS-2).

After a year of selling and using NEO, it became evident that the primary challenges were its lack of accuracy in the Slovenian language and the high costs relative to the value users received. Another problem that arose was the transmission of data to Google without having control over it and having to make requests to both the Slovenian and English models because of the use of words in both languages (for example, names of films). *"That is when we decided to develop something ourselves"* (TS-1). In collaboration with the Faculty of Computer and Information Science, which had already been active in AI implementation and voice recognition, Telekom entered into a joint venture for further work. However, when discussing the property of developed software and algorithms, *"once the knowledge is converted to an algorithm, it is not yours anymore, and this is a rising dilemma. (...) In the case of NEO and in general, we are interested that algorithms are our property"* (TS-4). The primary obstacle in developing a new machine-learning-based model was identifying patterns. To overcome this and make the process easier, Telekom *"replicated Google's methods and provided additional instruction on the new model"* (TS-1). Within six months, Telekom conducted a pilot project, and within one year, NEO was already in full production.

To comprehensively understand its functionality and why it represents a significant competitive advantage, some technical aspects of NEO are presented. *"We use voice control with a remote control that has a microphone on it. In our case, the user has to physically press a button on the remote control with the microphone icon. When the user holds the key down, their sound is recorded and sent in bits to the server where this sound is recognised."* While the user speaks, their speech is continuously sent to the server, and simultaneously, partial responses are received to confirm what has been understood. This process relies on ASR (automatic speech recognition) technology, which uses linguistic models. These models are trained to recognise sounds, specifically in the Slovenian language, for NEO's application. The result from the language model is a textual transcript of the user's speech, which is then displayed on the screen. Following this, Telekom engages in intent recognition, identifying the user's desired action based on the transcript. For example, if the user says "Pop TV," the model recognises the intent as "channel change" and identifies the entity, which is the channel name ("Pop TV"), enabling it to switch to that channel. The model is adapted for both Slovenian and English, as content exists in both languages. To improve NEO, Telekom is continually learning and adapting by randomly selecting audio recordings for validation. If, for instance, the recognition of the "Planet" program is problematic, they conduct tests, adjust model parameters, and retest with "Planet" audio recordings to enhance accuracy. Telekom has recently introduced an automated system update process to boost speed and enhance adaptability to changing demands. *"There is certainly no better provider for Slovenian, and for our case at the moment, that is because we adapt the model ourselves, and as we said, we can add changes very quickly and make the model work for our needs"* (TS-2).

"The voice search was only intended to make it easier to search the interface and the content" (TS-1), but this was, at the beginning, not the case. The fear of the device listening to users was a big problem, which is why *"for the NEO voice control to work, the button on the remote control must be clicked on or held down. If the user does not do this, the voice control will not work, or no recording will go to the server"* (TS-1). Moreover, the design of the remote is made intentionally without numbers to force the user to use voice control. Because of easy navigation, many users prefer to use voice recognition. *"It is also surprisingly widely used by the elderly when they see it works"* (TS-1).

"Artificial intelligence offers something more to the user" (TS-2), so Telekom has a great competitive advantage in this field. EON, which Telemach has, is a very similar technology but still uses Google's system, which is much worse. According to research done by external companies, the users use it a lot, but EON uses it very little.

3.6 Future of AI applications in the Slovenian telecommunications industry

With the growing popularity of chatbots and automatisation in customer service, which is a big part of telecoms, "We have been looking into what the often-asked questions are and are currently working on developing a bot, although it is not based on voice recognition, it is chat-based. However, along with the IT department, we have been discussing developing a bot using our existing voice recognition technology, which customers could use to ask questions. We are developing it with the help of ChatGPT" (TS-1).

Among future ideas for enhancing customer satisfaction, the company is exploring the reverse function of voice control, which involves text-to-speech synthesis. They first assess the market possibilities and user needs before determining new functionalities. When asked about their intention behind it and expected positive effects, “The main benefit is that it would allow people who are blind or visually impaired to better understand the interface, for example, the description of a film, a text that is harder to read for people who are visually impaired, and it would allow them to have that text read by a synthesised voice” (TS-2). Another Telekom’s pilot project might seem like a solution to a minor problem; however, it would bring many customers satisfaction. “We are working on auto-detection of a start time of a certain show, so when a customer rewinds to a start of a certain show, if it does not line up with the listed schedule, it will eliminate the extra work of rewinding to the actual start time” (TS-1).

Moreover, shifting focus towards AI applications in predictive maintenance and network optimisation, “With the incorporation of 5G, a lot of AI applications will come with the ability of processing on the edge of the network. It is up to 5G vendor, whose base station we use to install, to develop a system that would be applied to the whole macro network in Slovenia” (TS-3). Furthermore, “In telecommunications, there is a lot of talk about using AI for fault prediction, automatic error detection, and traffic diversion. Only big players can afford to develop that (...). All telecom companies dream of such a solution; however, it is near impossible without the vast resources and support and cooperation from all suppliers” (TS-1). Even though, in this area, the telecommunications industry is still not where it wants to be, they see realistic potential in AI applications with a 5G network in their pilot project with Luka Koper in logistics. “Predictive maintenance could be applied in the form of video analytics to eliminate human error. There would be several cameras used on the few cranes that are offloading. They would scan and search for any damage on containers, which would be reported along with the container code. However, video analytics requires a lot of storage capacity. With a 5G mobile network, you can offload this data to the edge of the network with a processor unit, taking the burden off the entire system” (TS-3).

Conclusion

The telecommunications industry is undergoing a significant transformation by integrating artificial intelligence (AI) into its core operations. AI is revolutionising customer service, advertising, network optimisation, predictive maintenance, and fraud detection within the industry. This chapter focused on the case of Telekom Slovenije, one of the leading players in the Slovenian telecommunications sector, to gain insights into how AI adoption and other innovative technologies impact the company and the industry as a whole.

Telekom Slovenije is proactively adapting to the changing cybersecurity landscape. They utilise a dedicated cybersecurity centre, combining AI-driven analysis and human expertise to detect complex threats. This integrated approach strengthens their security infrastructure, ensuring safety for services and clients. Telekom is committed to continuous improvement in cybersecurity practices as digital threats evolve.

The company recognises the importance of staying ahead in a rapidly evolving industry and continuously invests in technology development. Collaboration with universities and other partners ensures a steady influx of fresh talent and ongoing research. One of Telekom Slovenije's notable achievements is the development of its AI-powered voice recognition engine, NEO. The company improved accuracy, reduced costs, and gained control over user data by transitioning from paid solutions like Google's voice recognition to an in-house AI model. NEO represents a competitive advantage in the market and is well-received by users, including the elderly.

The company's successful deployment of 5G networks, emphasising private 5G campuses for large enterprises, positions Telekom Slovenije at the forefront of technological advancement. These networks offer superior reliability and coverage compared to traditional Wi-Fi, making them a compelling choice for businesses seeking efficient and secure connectivity.

Looking to the future, Telekom Slovenije is actively exploring AI applications beyond voice recognition. Chatbots, predictive maintenance, and network optimisation are areas of interest that hold the potential to further enhance customer satisfaction and operational efficiency. The company's dedication to improving accessibility through text-to-speech synthesis demonstrates its commitment to meeting diverse user needs.

Telekom Slovenije's journey into AI adoption showcases the industry's ongoing transformation and the company's proactive approach to innovation. As the telecommunications sector continues to evolve, AI will play a pivotal role in shaping its future.

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UNDERSTANDING THE ROLE OF AI IN ADVERTISING COMPANIES: THE CASE OF iPROM

Introduction

There are many fears and questions that AI technology will replace human efforts in marketing and advertising. However, it is necessary to be well prepared for the new era of AI in the advertising industry, embrace its positive features and learn from mistakes. AI will play a key role in quickly processing a large amount of advertising data and developing algorithms.

This chapter examines the influence and use of AI in the advertising industry. The practical example of the Slovenian company iPROM is used to illustrate how the marketing and advertising industry is changing with the help of AI and how individual processes are being optimised.

This chapter investigates the use of AI in the advertising industry and describes the company iPROM, which takes advantage of artificial intelligence. It has been developing and researching new technologies for advertising and communication for more than a decade. The role of AI at iPROM is then studied, and the results are analysed. The impact on business models and the benefits for customers in marketing and advertising are addressed. Among other things, the obstacles the company faces in implementing AI are mentioned. The research is based on in-depth interviews with key iPROM personnel.

1 The role and use of AI in the advertising industry

AI in advertising has become a powerful tool for businesses in many ways. It enables automation of processes to reduce costs, data analytics to gain financial insights, and much more. Marketing/advertising is the area where AI has the potential to have the most significant impact, enabling companies to optimise their operations, strategies, and understanding of customer needs and behaviours (Huang et al., 2020). AI also carries some risks, forcing companies to find the optimal middle ground between their marketing efforts, protecting and respecting privacy, and ensuring accuracy in conjunction with ethical and legal compliance (Deeb, 2023). Companies can quickly analyse what their customers like, their online behaviour, buying habits and patterns, and what messages they respond to (Marr, 2022).

With AI, companies can proficiently harness data with advanced learning algorithms and analytics, which enables them to decode consumer behaviour, predict more trends and create personalised campaigns. Moreover, these campaigns resonate with consumers on an individual level and include specific preferences, improving brand engagement. With chatbots, customer support is more efficient. AI can help predict and optimise ad placement, automate mundane tasks and enhance decision-making. This synergy between AI, marketing and advertising improves ROI and company value. The main risks related to artificial inteligence (AI)/ generative artificial inteligence (GAI) are accuracy, inherited risks and biases (which may arise from training data), and loss of intellectual property and data (Windoloski, 2023). European Association of Communication Agencies (2023) refers to the European Commission's Guidelines for ethical artificial intelligence, which established seven key requirements that should be complied with when implementing AI to ensure its safety, morality and responsibility. The requirements include human agency and oversight, technical robustness and safety, privacy and data governance, transparency, diversity, non-discrimination and fairness, environmental and societal well-being, and accountability.

The number of Slovenian companies using AI in advertising and marketing research is far higher than the European average (22.8 percent in Slovenia to 12.6 percent in the EU) (Table 1). In addition, AI is used in Slovenian advertising primarily in the areas of marketing or sales (19.2 percent) and ICT (22.8 percent). The use of AI in certain functions - especially marketing and sales and ICT security, is much higher in Slovenia than in other European countries. The development of AI in companies in advertising and marketing research is relatively balanced between full development and modification by own employees and the use of ready-to-use commercial software or modification by external providers. The biggest obstacle to using AI seems to be that they do not consider AI technologies useful. Ethical considerations and concerns about invasion of data protection and privacy do not seem to be an issue (Eurostat, 2023).

Table 1. AI technologies by sector in advertising and market research in 2021

Activities	All activities without the financial sector		Advertising and market research	
Countries	**EU-27**	**Slovenia**	**EU-27**	**Slovenia**
Indicators				
Enterprises use at least one of the AI technologies*	7.9	11.7	12.6	22.8
Enterprises do not use any of the AI technologies*	86.9	87.7	83.6	77.2
Use of AI for specific functions (% of all companies)				
Marketing or sales	1.7	3.1	3.9	19.2
Management of enterprises	1.2	2.4	2.3	5.7
ICT security	1.9	8.0	2.2	22.8
Development of AI				
Developed by own employees	2.1	3.2	5.2	10.8
Commercial software modified by own employees	2.0	4.1	4.8	13.6
Open-source software modified by own employees	1.6	3.1	4.5	5.5
Commercial software ready to use	4.0	8.9	7.4	6.4
Developed or modified by external providers	2.8	4.2	4.6	11.2

Note: *use technologies in line with Eurostat methodology

Source: Eurostat (2023).

2 Description of the company iPROM

iPROM is a Slovenian advertising technology (AdTech) company founded in 1999, providing digital marketing solutions mainly in the Adriatic region. The story of iPROM began in the grandparents' living room of one of the founders. It started with developing a price comparison website and evolved into a free website traffic analysis service, similar to today's Google Analytics, and a free online ad exchange service between web publishers. The latter two services aimed to promote the price comparison platform. *"After three years, iPROM launched an advertising network that marked its entry into the AdTech and advertising industry"* (iPROM-1, Table 4), reflecting iPROM's commitment to innovation, which is still evident today.

iPROM captures 2.16 percent of the market operating in the activity defined as Advertising Agencies in Slovenia (Bizi, 2023). The company is ninth with regard to revenues from sales in 2022 in Slovenia (Table 2). In 2022, their ROE was 0.27, ROA was 0.18, and operating revenues to operating expenses were 1.0. Moreover, their value-added was 1,601,730 EUR and has been declining since 2020 (Bizi, 2023). Concerning employees, 35 people were employed at iPROM in 2020, 38 in 2021, and 42 in 2022 (Ajpes, 2023).

Table 2. Financial data for selected Slovenian advertising agencies in 2022 in euros

	Company name	Revenues from sales	Value added per employee
1	**MMS KOMUNIKACIJE (Publicis/ Saatchi …), d.o.o.**	16,730,282	51,634.25
2	**FUTURA DDB, d.o.o., oglaševalska agencija**	12,614,716	49,956.28
3	**PRISTOP, družba za komunikacijski management, d.o.o.**	8,879,772	55,604.29
	…		
9	**iPROM, optimizacija akcij na internetu, d.o.o.**	5,740,235	38,136.43

Source: Own work, based on Marketing Magazin (2023) and Bizi (2023).

iPROM uses a hybrid approach, where revenues from services fund technology development. The aim is to challenge the AdTech solutions of tech giants like Google, Meta, and Amazon by providing independent ad solutions and prioritising user privacy and data protection. Since this goal requires large funds to be allocated to R&D, this results in a lower value added per employee than the largest companies in the industry (see Table 2). *"We actually have an excellent result considering that we do everything ourselves. In other words, we are the only ones with our own design, our own AdTech, which other agencies outsource. We have developers; we have a complete implementation, I will not only say creating ads, preparing ads, but also actually placing the ads"* (iPROM-2, Table 4). Moreover, *"iPROM has been funded, up to this point, solely by our co-founders. There have been no external investments, which is also why the main purpose of offering marketing service activities is to cover the costs related to R&D"* (iPROM-3, Table 4).

Table 3. iPROM product and services offer as of 2023

iPROM Product	Description
iPROM Programmatic Platform	• Comprehensive programmatic media buying solution. • GDPR compliant with robust data privacy protection. • Advanced targeting and segmentation features.
iPROM Private DMP	• First-party data management platform for advertisers. • Empowers iPROM clients to leverage the first party data. • Enhances targeting and personalisation of ad messages.
iPROM Ads formats (e.g., iPROM Spider Ad™, iPROM Native, etc.)	• Focus on user experience with multiple ad formats. • Versatile functionalities for complex communication strategies.
iPROM Display	• Focus on precise targeting rather than leasing advertising space. • Combines computational advertising algorithms, a broad selection of exchange and direct publisher display inventory, and real-time insights.
iPROM Mobile	• Helps communicate and connect to mobile audiences. • Customising ads and engaging the most profitable consumers.
iPROM Video	• Dynamic and highly creative video advertising formats. • Offers custom video analytics to measure impact.
iPROM Search	• Costs of presence on search engine optimisation. • iPROM is also a Google Premier Partner.
iPROM Social	• Provides information on a digital media. • Optimised data acquisition for planning, design, implementation and ongoing optimisation of campaigns on clients' websites.
iPROM Real-Time Creative	• Processing and utilising big data. • Automated process of ad creatives generation in real time. • Based on the behavioural data of digital media users.
iPROM GPT AD Format	• An ad format combining chatbots and AI, such as ChatGPT. • Utilises AI-powered conversations for meaningful connections.
iPROM OnSite	• Sales support and improvement of sales processes within advertisers' webpages. • Uses smart algorithms which analyse data in real time.
iPROM Email	• Services: strategy, consulting, design, content optimisation, and mailing list management. • In-depth reports of effectiveness and improvement opportunities.
iPROM Predictive	• Uses Valicon consumer research and iPROM media consumption analysis for predictive targeting, which reduces media waste. • Identifies users who have shown interest in a product or service. • Predicts correctly with an 80 percent probability.
iPROM Analytic	• Streamlined programmatic solution to maximize ad revenue without added complexities. • Dedicated yield optimization in the global programmatic ecosystem.
iPROM Yield	• Aids advertisers in managing and analysing customer data with advanced machine learning and automation to help discover deeper customer insights. • Utilizes independent analytical tools for effective data insights.
iPROM AdServer	• Intuitive campaign management for advertisers, publishers, and agencies offering complete data control. • Enables optimized management of programmatic and direct sales to maximize digital ad revenue.

Source: Own work based on iPROM (2023b) and iPROM-4 (Table 4).

iPROM distinguished itself in the region by its strategic choice to offer proprietary solutions such as iPROM Private DMP and iPROM DMP. DMP, or data management platform, is a platform which allows advertisers, agencies, publishers, and others to track their target audience and campaign data and combine it with data from their other marketing activities. iPROM Private DMP solution enables more efficient media buying and better campaign planning based on first party data, with the help of behavioural targeting and expanding the target audience with third party data. Advertisers and agencies usually use a DMP platform for better buying, whereas publishers use it for audience segmentation and more efficient selling of advertising space (Cetin et al., 2020). Additionally, iPROM offers a range of other products that provide innovative and technologically advanced ways of data collection, sorting and management (Table 3).

Moreover, iPROM would like to transition from the previously mentioned hybrid approach: *"iPROM's vision is to transition into a product-oriented enterprise, which is a transformation that has been in progress for the past three years. The company's approach involves integrating niche expertise into specialised solutions with high added value and distinctive advantages and making them accessible to both agencies and businesses"* (iPROM-1).

3 Research methodology

This study aimed to gain comprehensive insights into iPROM's operations, strategies, and the challenges it faces using AI technology within the company and for the services it provides. To address these objectives, in-depth interviews were conducted in August and September 2023, with five interviewees with key roles at the company (Table 4). Three of those had follow-up online interviews. A diverse research approach was employed, using interviews, observation, and analysis of archived sources to ensure credibility and validity by triangulation (Caniato et al., 2018).

Table 4. List of interviewees

Interviewee code	Role in the company	Gender	Interview type	No. of interviews
iPROM-1	Co-founder	Male	Digital correspondence	1
iPROM-2	COO	Female	In-person & Online	2
iPROM-3	Head of Corporate Communications	Female	In-person & Online	2
iPROM-4	Head of R&D and iPROM Labs	Male	In-person & Online	2
iPROM-5	Head of IT/Programmers	Male	In-person	1

Source: Own work (2023).

Data collection was mainly focused on the questions and content provided by the company which allowed us to address the following six main topics: (1) the evolution of AI technologies utilisation in iPROM; (2) the impact of AI on the business model and value for customers; (3) barriers to implementation of AI; (4) use of AI for internal processes; (5) educating employees on the use of AI; and (6) value for the end consumer and ethics orientation.

4 Results

4.1 Evolution of AI technologies utilisation in iPROM

"iPROM has been utilising AI for the past decade, with a recent surge in popularity due to increased hardware accessibility" (iPROM-4). The company recognises that AI is a broad concept; however, they consider deep algorithms as true AI and distinguish simple if statements as not AI. iPROM's journey with AI began around 2011 when they started using mathematical models for sales analytics and web sales analysis, which marked the initial stages of their artificial intelligence adoption.

In 2014 and 2015, iPROM expanded its AI by using semantic analysis to match the content of a webpage or context and ads, as well as sentiment detection (positive or negative connotation). Today, they use AI extensively in their operations, particularly in their solution DMP and Private DMP. iPROM Private DMP aims to ensure a large enough and trustworthy database for clients by collecting advertiser first party data, with which iPROM can employ AI for clustering methods for user grouping. iPROM Private DMP ensures GDPR compliance by actively seeking user consent without compromising personal data. *"It keeps the client's data private from other firms in the industry, unlike Alphabet, Meta, Amazon, which provides a massive open database for all service users"* (iPROM-5).

Moreover, iPROM uses the machine learning (ML) method of finding likeness. *"The ML/AI method of searching for likeness means searching for similar users to those who have already expressed an interest in something"* (iPROM-4). This approach aims to broaden the target audience by predicting user interest, using online behaviour data of those already identified as targets for marketing. With this method, iPROM can also decide the size of the target segment as stated, *"you can determine the size of the group according to the degree of similarity, so if you have a bigger budget, this means that you can also target less similar users"* (iPROM-4).

iPROM also utilises AI for ad campaigns by automating processes, analytics optimisation and prediction, dynamic targeting and leasing of advertising space, personalisation of ads, and ROI optimisation (iPROM, 2023b).

Automating processes refers to using AI not only for uploading banners but also for creating content, choosing appropriate online channels, monitoring and reporting. AI is used in analytics optimisation and prediction at iPROM for pattern recognition and large datasets, as well as for forecasting based on historical data by looking for similarities. Moreover, AI can help with fraud detection, which in advertising is referred to as 'ad fraud'. An example of ad fraud that iPROM must deal with is one online user clicking on the same ad in hopes of generating more money, as, in some cases, the money received from advertisers for having ads on websites is based on the number of clicks a certain ad receives. *"The detection of ad fraud is extremely difficult, but artificial intelligence makes it easier to detect"* (iPROM-5).

Next, AI is used in dynamic targeting and leasing of advertising space. *"AI also helps us with identifying the buying process and, more importantly, where, in what phase, the user is"* (iPROM-5). Knowing which phase of the consumer decision journey (CDJ) a digital user is in helps iPROM determine the appropriate targeting and leasing of ad space. Moreover, iPROM uses AI for ad personalisation by showing and determining relevant ads for digital users. One way of doing this is through A/B testing, where two or more ads run simultaneously, and responsiveness is tracked among digital users to identify the better ad. Finally, iPROM uses AI for ROI optimisation by avoiding media waste. *"We adjust the display frequency according to analytics – that is, we look at whether there is interaction or not and, based on this, determine the optimal frequencies"* (iPROM-5).

4.2 Impact of AI on the business model and value for customers

iPROM recognises AI's value to its business model: *"We believe AI has a good impact. We are enthusiasts in this field and strive to follow those solutions for which we see an added value for the customer and legal compliance. We will definitely implement those solutions"* (iPROM-3). Here, iPROM DMP and iPROM Private DMP, the fundamental solutions they offer to their clients, should be mentioned. They answer one of the common questions in the AdTech industry – data ownership. *"Compared to advertising platforms such as Google, the main benefit of working with our DMP solutions is the privacy of the col-*

lected data. When advertising on Google, for example, all data exchanged in the client's advertising is owned by the platform and becomes shared data, which can be used further" (iPROM-3). In other words, a client holds no data ownership. However, when working with iPROM Private DMP, by contract, a client has full ownership of the data. iPROM will not treat it as shared data and use it in any other case. *"Advertising platforms have a stronger structure, but with it and its bidding concept, prices of ad placements made by iPROM according to the client's private data can be lower than those on previously mentioned platforms"* (iPROM-4).

"Our competitive advantage is that we are agile. We can listen to the market and adjust quickly. We are constantly developing new solutions and implementing the ideas of our clients as well as developing our own. An example of one of our newest solutions is the iPROM GPT ad format" (iPROM-2). This ad format couples the idea of chatbots and AI, such as ChatGPT. *"It uses a large language model and provides digital users with an interactive ad, where individuals can make meaningful connections with the advertiser through AI-powered conversations on a personal level and can be redirected to advertisers' sites"* (iPROM-5).

Both iPROM and its clients benefit from a demonstrable competitive edge by utilising these solutions, as they no longer rely on generic technological platforms. *"The utilisation of iPROM's AdTech solutions empowers clients with data independence, sustainable competitive advantages, and robust data protection measures against competitors, all while maintaining compliance with European privacy regulations like GDPR"* (iPROM-1).

4.3 Barriers to the implementation of AI

Despite being a pioneering player in AdTech, over the past seven to eight years, since the use of AI in their solutions has been mainstream, iPROM has faced some challenges with the implementation of AI. Firstly, understanding AI has been a challenge. In the beginning, acquiring knowledge was limited to computer scientists, as it used specialised vocabulary and was based on mathematical models. It was less interesting to learn about AI than it is nowadays. *"As recognised by many in this field, the launch of OpenAI solutions such as ChatGPT in November 2022 was a tipping point that led to a great mass not only hearing about but also using AI solutions that became easy to use for the average consumer without having to understand the technology behind it"* (iPROM-4). At that point, the use of AI became widespread in everyday life, and the journey to start using it has become shorter and almost instant. *"Nowadays, even some of the code is open-source, to be used freely for future development, which presents a great opportunity to develop AI-fueled solutions faster and more easily than before"* (iPROM-4). Additionally, *"Processing power, which was also a significant constraint due to its high cost when starting out with AI-powered solutions, has now become more accessible and advanced, able to handle large amounts of data and be able to process big data operations"* (iPROM-5). Big data is the core of iPROM's operations. iPROM recognises the implementation of AI and new AI-powered solutions as a continuous challenge. As the co-founder of iPROM said, *"The path of transformation is a challenge that primarily requires a change in the mindset of employees. That is why we are gradually introducing new people in management positions who will help us with this"* (iPROM-1).

4.4 Use of AI for internal processes in iPROM

"In iPROM, we are integrating AI technologies not only in our services but also in internal processes to boost efficiency" (iPROM-3). Since implementing AI for internal processes, all interviewees believe that the benefits include time-saving, idea generation and overall efficiency of content production. During the interviews, an overview of the utilisation of AI technologies across departments was provided (Table 5). They first utilise AI for Content and Language Tasks. At iPROM, several roles, including the CEO, members of the marketing team, and creatives, harness AI for content-related tasks, which include word processing, generating slogans, translations, and crafting presentations. Consequently, they can deliver compelling and data-informed content more efficiently, making it possible to skip the long process of working with various content writers and send content straight to a proofreader. Secondly, they utilise AI solutions in Technical and Development Roles. The Chief Technology Officer (CTO) and programmers are at the forefront of AI integration for technical tasks, which include programming, software script writing, and creating dynamic creatives. These AI applications enhance technological advancements and streamline software development processes. The utilisation of AI for AI-Powered Data Management includes serving ads efficiently, ensuring brand safety through semantic analysis, and sophisticated data processing in the Data Management Platform (DMP). *"iPROM Private DMP's job is to collect first party data of the advertiser. An AI method of clustering is then used over this data. However, this database must be constantly updated as some users are deleted, and new ones are acquired over time"* (iPROM-4). Additionally, *"This does not interfere with the user's personal data. We operate solely with non-identifiable data, such as*

behavioural data, based on browsed content and connected with cookie based identifier" (iPROM-3). Using AI in data management strengthens iPROM's capabilities in data-driven decision-making. The outputs of widespread AI-powered programs and solutions are mainly used for idea generation within iPROM, and the produced content is continuously overseen by a person before possible distribution to the public.

Table 5. Use of AI for internal processes in the company iPROM

CEO	• **Writing:** word processing, ideas for slogans, translations. • **Exploring prompt engineering:** training the iPROM bot, training iPROM GPT ads.
Marketing	• **Writing:** word processing, ideas for slogans, translations, ideas for presentations.
CTO	• Programming, writing software scripts, formats or dynamic creatives.
Head of iPROM Labs	• Serving ads, semantics, brand safety. • **Data processing in DMP:** clustering (categorisation), similar search, recommendation algorithm for similar products.
Programmers	• Programming, writing software scripts.
Creatives	• **Writing:** word processing, ideas for slogans, translations, training iPROM GPT ads. • Researching AI tools and methods for design and visualisation.

Source: iPROM, (2023b).

4.5 Educating employees on the use of AI

In iPROM, employees also take responsibility for sharing knowledge and skills. They have a monthly internal educational event which informs employees over departments about new solutions, new products and cases for clients, processes and development in iPROM. They help coworkers implement AI solutions safely by themselves to improve work efficiency. With emerging and daily evolving AI use in business at large and advertising, employees must develop skills in AI-driven marketing, including expertise in data management, cloud services, and AI applications. Business acumen, proactive experimentation, and strong marketing capabilities are essential for aligning AI strategies with business goals and optimising marketing performance. Focusing on organisational performance metrics, such as market share, growth, and innovation, is vital for staying competitive in the AI-powered marketing landscape (Mikalef et al., 2023). *"We care about staff development; we have a mentorship program. When someone new joins our Research and Development Team, we allocate some time to onboard this person so they get to know what data driven advertising, data management and DMP is, how it works and learn about the processes at iPROM. Later on, we encourage and support employees in taking on various* *training courses, and we have large knowledge transfers when we collaborate with outside institutions such as the Jožef Štefan Institute"* (iPROM-3).

4.6 Value for the end consumer and ethics orientation

iPROM recognises its role in the safety and well-being of digital users. They address three pillars in their operations: the digital user, the media or where the ad is shown, and the advertiser. They protect digital users by not exposing them to inappropriate content and giving them control over closing ads. For the media, they do not flood the site with ads, and for advertisers, they enable suitable adverts on suitable websites to suitable users. Moreover, iPROM has emphasised the importance of AI for better ad targeting, as ads are less invasive and more relevant for users. Additionally, with this, iPROM is more successful in its offer to clients. *"We strive to be innovative, comply with the highest privacy and data protection guidelines and be a system integrator of various technologies in the field of advertising"* (iPROM-3).

Additionally, iPROM recognises the use of ad blockers; however, they do not believe this significantly hinders their work, as the use of ad blockers is relatively low and is limited to non-mobile devices. They aim for user-friendly ads that respect privacy and consent and avoid surpassing ad-blockers, knowing it would harm their reputation by showing ads to cautious users. iPROM has the well-being of digital users in mind while striving to achieve its customers' goals.

Conclusion

AI has revolutionised the advertising industry, offering unparalleled capabilities in data analysis, customer insights, and targeting. However, this technological advancement also raises crucial questions about privacy, ethics, and responsible use of AI. Key findings are summarised in Table 6.

iPROM's decades of experience with AI technology has had a significant impact on its services, from analytics to advertising campaign optimisation to internal operations efficiency. Their innovative approach to AI has transformed their business model, which is designed to ensure data privacy and user-friendly advertising. iPROM Private DMP stands out by giving its clients full ownership of the data - a rarity in the industry - ensuring both customer value and compliance.

Table 6. A summary of key research findings

Subchapter	Key findings
Evolution of AI technologies utilisation in iPROM	• Growth driven by improved hardware accessibility; • Deep algorithms as true AI; • Semantic analysis and sentiment detection; • DMP solutions for clustering, ad targeting, personalisation, and ad optimisation.
Impact of AI on the business model and value for customers	• DMP and iPROM Private DMP; • Client data ownership; • Strong data protection; • GDPR compliance; • Innovative iPROM GPT ad format.
Barriers to the implementation of AI	• Initial AI complexity and high cost of big-data processing; • Changing employee mindsets through management.
Educating employees on the use of AI	• AI integrated into their services and internal processes; • AI utilisation in content and language tasks, technical and development roles, and AI-powered data management; • AI strengthens efficiency, human control.
Value for the end consumer and ethics orientation	• Digital user safety as a priority by content, non-intrusive ads and user control; • Commitment to innovation; • Data protection guidelines, integrating diverse advertising technologies; • Positive user experience, privacy and consent of the digital user.

Source: Own work (2023).

As early adopters of AI in 2011, they faced some challenges, such as understanding complex AI concepts and high data processing costs. The widespread accessibility and open-source nature of AI solutions have accelerated the integration of AI at iPROM. Internally, AI has improved efficiency in content creation, technical tasks, and data management. Their commitment to development through cross-departmental learning and external training demonstrates their dedication to continuous learning of AI expertise.

iPROM's strategic use of AI represents an evolving business model that prioritises privacy and delivers greater value to customers. Their vision encompasses AI technology development to shape the future of digital advertising. Despite their early pioneering role in AdTech within the Adriatic region, the company has since relinquished this position. Their investments in hiring external partners and in-house development are resulting in lower added value per employee. However, this potentially strengthens relationships with their clients and ensures long-term survival in the competitive industry.

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AI'S ROLE IN WHOLESALE MEDICINE AND MEDICAL EQUIPMENT: SALUS GROUP CASE STUDY

Introduction

In today's dynamic marketplace, recognising the profound impact of AI on businesses is essential, as it offers distinct advantages like significantly reducing errors (by 20–50 percent) and improving supply chain management efficiency (McKinsey, 2022). Sysco Corporation, a global leader in food distribution and wholesale, employs AI and machine learning to strengthen demand forecasting, leading to reduced inventory costs, heightened customer satisfaction, and improved supplier collaboration (CIO, 2023).

This chapter explores the impact of artificial intelligence (AI) on the healthcare distribution industry, focusing on wholesale medicine and medical equipment. Using Salus Group as a case study, the presence, benefits, and drawbacks of AI tools in their business operations are analysed, highlighting how AI is driving transformation, service optimisation, and business growth.

Salus Group, based in Ljubljana, Slovenia, is a key player in pharmaceutical distribution and medical equipment, operating across multiple European countries through its 12 subsidiary companies. Their mission is to enhance health and well-being by providing comprehensive distribution, promotional, and sales services for medicines and medical devices (Salus, 2023). Within Salus Group, AI plays a pivotal role in enhancing operational efficiency and elevating healthcare services. AI-driven inventory management systems are employed for real-time pharmaceutical stock monitoring, minimising product shortages, and optimising supply chains.

Additionally, Salus uses AI-powered data analytics to gain market insights, enhance decision-making and tailor offerings to meet customer demands effectively.

The chapter provides an overview of AI usage in the Slovenian and EU wholesale sectors and investigates an analysis of AI implementation at Salus Group. Interviews with department leaders establish the benefits and challenges associated with AI tools in the company.

1 The use of AI in wholesale

1.1 General overview

Among companies in wholesale, only 12 percent of distributors currently employ artificial intelligence, primarily in their sales and marketing departments (Eurostat, 2021). In marketing and retail, big data analytics is used for personalised customer profiles and prediction of purchasing habits, while AI improves trend analysis, logistics planning, and stock management (Dwivedi et al., 2021). Technology is sometimes used to analyse customers' feedback and complaints as well as social media data to improve the products and services offered (Kudumala, 2022). In B2B sales, AI streamlines the sales funnel by automating tasks like scheduling, targeted communication, content enhancement, and chatbots for personalised content, objection handling, and post-order communication (Paschen et al., 2020).

Different frameworks, such as the Artificial Neural Network (ANN), are used to predict demand more accurately and improve forecasting. AI reduces economic losses by 41 percent in predicting the selling price and 56 percent in estimating the buyer's demand (Bottani et al., 2019). AI technologies within the wholesale sector improve firm productivity, while the use and intensity of AI positively influence sales and value-added (Czarnitzki et al., 2023). German companies from different industries, including wholesale, reported that using AI increased sales by approximately 14 percent. The combined effect of higher innovation engagement, investments in software and databases, and sectoral heterogeneity by industry improved it further. However, there are concerns about the impact on jobs and inequality as well as the policy measures needed to mitigate these (Czarnitzki et al., 2023).

AI is reshaping retail with applications like warehouse automation and legal document analysis. Automated inventory management, using RFID tags and image recognition, enhances efficiency and cuts costs. For example, according to

Amazon's chief technologist, implementing robotics into inventory management increased storage efficiency by more than 50 percent (Gonzalez, 2017). However, algorithmic staffing optimisation may intensify workloads and limit flexibility, fostering internal competition among employees. Additionally, the rise in e-commerce, driven by AI, prompts job security concerns for warehouse and delivery workers (Hunt & Rolf, 2022). General challenges of using AI in different aspects of wholesale business include the lack of integration in the supply chain, poor data management and standardisation, problems in change management, and privacy concerns (Egorov et al., 2020).

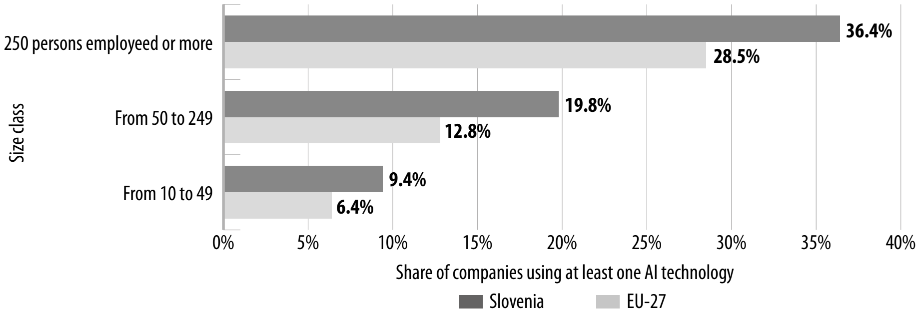
1.2 AI use in wholesale in Slovenia and the EU

Slovenia exhibits a more proactive approach when integrating new AI technologies compared to the European Union, where in 2021, around 11.7 percent of companies in Slovenia (7.8 percent in the EU 27), excluding the financial sector, employed at least one listed AI technology. This difference is even more significant in the wholesale sector, where around 12.3 percent of companies in Slovenia have been incorporating at least one of the existing AI technologies and only 4.8 percent in the EU (Table 1). These technologies cover various applications, from text mining to image recognition, underscoring the sector's eagerness to harness AI's transformative potential.

Companies within the wholesale sector employ AI technologies for a range of purposes. In Slovenia in 2021, 2 percent of companies (compared to 1.9 percent in the EU) demonstrated improvements in their marketing and sales efforts by utilising AI. Additionally, Slovenia leads in optimising production processes with 2.9 percent (1.3 percent in the EU), while others explored AI's potential in logistics, ICT security, human resources management, and more. These insights reflect the sector's multifaceted approach to leveraging AI for enhanced efficiency and competitiveness (Table 1).

AI technology adoption varied significantly across company sizes within the wholesale sector in 2021, with pronounced differences observed in Slovenia compared to the EU. Notably, small Slovenian companies (10–49 employees) exhibited a higher incorporation of AI, with 9.4 percent compared to the EU's 6.4 percent. In medium-sized companies (50–249 employees), Slovenia leads with 19.8 percent AI integration, exceeding the EU's 12.8 percent. Large Slovenian companies (250 employees and more) also stood out, with 36.4 percent employing AI compared to the EU's 28.5 percent (Figure 1).

Figure 1. Use of AI technologies by size class of companies in percent in 2021



Source: Eurostat (2023).

Table 1. AI technologies by sector comparing EU and Slovenia in 2021 *

	All activities without the financial sector		Wholesale trade, except for motor vehicles	
	EU-27	Slovenia	EU-27	Slovenia
Indicators				
Enterprises use at least one of the AI technologies*	7.9	11.7	6.8	12.3
Enterprises do not use any of the AI technologies*	86.9	87.7	90.1	87.7
Use of AI for specific functions (% of all companies)				
Marketing or sales	1.7	3.1	1.9	2.0
Production processes	1.6	3.0	1.3	2.9
Organisation of business administration processes	1.8	1.6	1.8	2.0
Management of enterprises	1.2	2.4	1.5	2.1
Logistics	0.8	1.0	1.0	2.4
ICT security	1.9	8.0	1.7	8.5
Human resources management or recruiting	0.7	0.3	0.5	N/A
Obstacles to using AI				
Companies use AI technologies for at least one of the purposes**	5.0	11.5	4.8	12.3
Companies who ever considered to use one of the AI technologies*	N/A	5.9	N/A	5.7
Companies do not use AI technologies because the costs seem too high	N/A	3.9	N/A	3.8
Companies do not use AI technologies because of a lack of relevant expertise	N/A	3.7	N/A	4.8
Companies do not use AI technologies (mismatch with existing equipment/systems)	N/A	3.4	N/A	3.8

* Use technologies for performing analysis of written language, converting spoken language into machine-readable format, generating written or spoken language, identifying objects or persons based on images (image recognition, image processing), machine learning for data analysis, automating different workflows or assisting in decision making, enabling physical movement of machines via autonomous decisions based on observation of surroundings.

** Marketing or sales, production processes, organisation of business administration processes, management of enterprises, logistics, ICT security, human resources management of enterprises.

Source: Eurostat (2023).

The most common reasons for non-adoption in the wholesale sector in Slovenia are lack of expertise (4.8 percent), concerns about costs (3.8 percent) and compatibility with existing systems (3.8 percent), while the data for the EU is not available for comparison (Table 1). While some companies develop their AI solutions in-house (3.2 percent in Slovenia, 1.6 percent in the EU), others modify commercial software (5.3 percent in Slovenia, 2.1 percent in the EU) or utilise open-source solutions (5.7 percent in Slovenia, 1.4 percent in the EU).

2 Company description

Salus Group is a wholesaler of medicines and medical equipment, originally based in Ljubljana, Slovenia. It operates in the supply of medicines, food supplements, medical devices and quality and innovative services that bring health and well-being to people, as it specialises in offering an integrated service of distribution, promotion, and active sales as well as accompanying services to bring medicines or medical devices to market. Salus aims to strengthen its position for the distribution of pharmaceutical products and services in Southeast Europe by conducting business following six core values: health, proactiveness, responsibility, honesty, family, and a sense of belonging (Salus, 2023).

Table 2. Key financial data for Salus, industry and economy

Categories	Salus	Wholesale trade, NACE code G46
Revenue (in millions)	414.5	2,825.7
Average number of employees (hours worked in the fiscal year)	149	3,395
Turnover per employee	2,781,099	832,298
Added value per employee	102,099	101,357

Source: AJPES (2022), Statistical office of the Republic of Slovenia (2023), Salus (2023).

Salus Ljubljana d.d., which is a parent company of the group, is present in the markets of Central and Eastern Europe, predominantly in the Balkans, having 12 companies under the group name like Sanolabor and Carso, which became a part of the group in 2018, as well as other regional players in the medicines and medical equipment industry (Salus, 2023). The business strategy for 2018–2022 outlined ambitious growth plans relying on increased distribution of pharmaceutical products and sales of services in Slovenia and Southeast Europe, quality and cost-effectiveness, efficient execution, digitalisation, and employee commitment. In 2022, its added value per employee was EUR 102,099 (Table 2). For the ongoing financial year 2023, Salus Group ambitiously targets EUR 540 million in net sales revenue, EBITDA of EUR 17 million, and a net operating profit of EUR 8.9 million (Salus, 2023).

In its 2023–2027 strategic plan, the company aims to consolidate its position in the Slovenian market, particularly in wholesale (Skupina Salus, 2023). Cost efficiency and digitalisation are pivotal for long-term success, involving process optimisation and digital strategies. Leveraging AI solutions and historical data in the past, they achieved over 90 percent accuracy in demand forecasting, reduced inventory by more than 65 percent, and cut manual workload, resulting in substantial cost savings (Perko, 2022). Regardless, the number of employees has been slowly growing throughout the past five years, while the number has tripled in the last decade. Geographic expansion into Central and Eastern Europe (CEE) is a priority, targeting 17 CEE countries by 2027. Employee engagement and ethical conduct are emphasised, fostering transparency and commitment to high standards. Furthermore, sustainability is integral, aligning business goals with sustainable practices while stringent quality and compliance standards are upheld, reinforcing its reputation as a reliable partner. The company intends to allocate investments toward representation and innovative pharmaceuticals to drive future growth.

3 The use of AI in Salus

3.1 Research methodology

Qualitative analysis was conducted to understand the use of AI in Salus more thoroughly. In total, nine interviews with heads of different departments in the company were conducted (Table 3), exploring the types of technological solutions used, those related to AI, the purposes and goals of their use, the motives for implementation, and the expected and observed impacts. Moreover, the challenges related to the use of AI in the department were examined, and the perceived future potential management sees for integrating AI into everyday business. The interviews were held from August 28 to September 7, 2023, in the company; each interview lasted up to one hour.

Table 3. List of interviewees, their positions, and technologies used by the department

Code	Interviewee's position(s)	Gender	Technologies in use
Salus-1	CEO, President of the board of directors	Male	Microsoft Navision, WMS, DocuWare, QlikSense, Machine learning
Salus-2	CFO	Female	ChatGPT, Document Indexing
Salus-3	Head of R&D department	Female	Microsoft Navision, WMS, DocuWARE, QLIKSense, CHAT GPT
Salus-4	HR manager	Female	HR potentials
Salus-5	Head of sales department	Male	QlikSense, an integrated management system
Salus-6	Head of marketing	Male	ChatGPT
Salus-7	Head of IT	Male	Microsoft Navision, Microsoft Office in the cloud
Salus-8	Head of procurement	Female	Machine learning

Source: Own work (2023).

3.2 General corporate orientation and strategy

Salus uses Microsoft Navision for enterprise resource planning and a Schaeffler Warehouse Management System for automated inventory management. They also employ tools like DocuWare for document management, Qlik Sense for controlling, and a machine-learning-powered procurement and inventory system. This AI system continuously learns and optimises ordering processes based on daily purchasing activities, showcasing its adaptive nature.

In terms of competition, Salus competes with two other firms that rely on SAP, positioning themselves as technologically advanced in the field. *"At the top end of the scale in terms of how we are digitalised, even my predecessor was very much in favour of it. He had the right passion, so it is good to see that we have made some changes in that respect"* (Salus-1). Their primary challenge during the transition to a standardised solution was focused on risk management, emphasising the importance of system robustness and transparency, ultimately reducing dependency on system maintenance, which was at the time dependent on one person and was quite unfavourable according to Salus' employee, *"the whole company kind of depended on when he would have time when he could do some renovation of whatever or meet some requirement, plus if anything happens it is quite a big risk"* (Salus-1). Although quantifying the financial benefits of this transition posed challenges, the interviewee underscored the significance of enhanced system efficiency and the capacity to accommodate growth without substantial increases in staffing. Salus claims to have successfully retrained staff from logistics roles to adapt to automation initiatives.

The overarching corporate strategy of Salus revolves around cost-effectiveness, improved user experiences, and exploring potential revenue streams through digitalisation, making the business scalable, including advertising on digital screens within pharmacies. *"This is a pilot project on how digitalisation can also help generate revenue because this is now quite a business for us. We meet with some manufacturers of food supplements, medical devices, we make a campaign, and one element of this campaign is also advertisements on digital screens in pharmacies"* (Salus-1). While discussing legal challenges, it was emphasised that *"it has nothing to do with AI, but more to do with legislation and regulation. We could do more in the area of patients having better care. In several directions – one is home care. That was something that started years ago and then stopped quite a bit"* (Salus-1). The companys stressed the need for regulatory adjustments to facilitate improved patient care, encompassing services like telemedicine and telepharmacy.

3.3 Information technology

Salus's IT department assumes a crucial role in the company's operations, overseeing technological advancements and the integrity of critical systems. This analysis delves into their approach to technology adoption, incorporating machine learning, outlining future system upgrades, and emphasising strategic considerations, particularly in data management.

Recognising that Microsoft Navision, their ERP system, may not be at the forefront of technological advancements, Salus relies on it as a critical component of their daily operations, but with the head of the IT department suggesting that *"from that point of view, we think that in about two or three years we will probably have to switch to a new version"* (Salus- 7). Additionally, Microsoft Teams plays a pivotal role in internal communication, serving as a messaging and conference system for the company.

The Warehouse Management System (WMS) they are using showcases a well-structured and automated process that efficiently handles orders, inventory, and delivery, all while maintaining a paperless workflow. *"The whole story is paperless, and we no longer print delivery notes or invoices"* (Salus-7). Machine learning algorithms enhance procurement by using historical data to make purchase suggestions, improving efficiency. Despite initial resistance and process change challenges, Salus acknowledges that effective communication is vital for successful technology adoption. The IT department sees various opportunities with AI adoption, including regulatory compliance, security enhancements, process optimisation, and functional improvements. The organisation aims to integrate AI with existing systems to stimulate growth and improvement, not as a replacement.

The IT department has a clear vision of upgrading its systems in the future, demonstrating its commitment to staying current in a rapidly evolving technological landscape. A significant point of consideration revolves around data management. While the organisation has moved desktop applications like Microsoft Office to the cloud *"to exchange documents, work on the same documents, and so on"* (Salus-7), databases remain on-premises primarily due to cost considerations.

3.4 Research and development (R&D)

In the R&D department at Salus, AI is not directly integrated into their day-to-day operations, but they have proactively sought to embrace AI-driven innovations in their 5-year strategy. A part of it *"is that Salus is also willing to invest in start-ups ...that are in health care and that have some connection with [Salus] strategy and [its] strategic objectives"* (Salus-3). An example is machine learning for disease prediction; another involves using AI to improve children's eyesight through engaging video games, although the specific company name remains undisclosed.

During presentations to potential partners, Salus highlights their utilisation of AI technologies, such as the Schoeffer Warehouse Management System (WMS), Navision ERP, and QlikSense for procurement forecasting. These AI-enabled tools have enhanced the traceability of their supply chain. As the head of the development department says, *"We have a modern warehouse here, and this traceability is very important"* (Salus-3).

In the future, they foresee AI's transformative potential for their operations and are open to using it for decision-making, communication, translation, and start-up scouting. This approach aligns with their commitment to health improvements and sustainability contributions. The competitive landscape reinforces their belief that AI adoption will become a necessity. *"We will all be* *forced to use it because if we do not, the competition will overtake us, or we will be too slow"* (Salus-3). Salus envisions optimising various internal processes with AI, making them more efficient and effective. However, they acknowledge the challenges of limited AI knowledge, concerns over cybersecurity, and potential resistance to change, especially among older staff members. Nevertheless, they remain committed to exploring the possibilities that AI presents, as they believe it can play a crucial role in shaping their future success.

3.5 Human resource management

The HR department is in the early stages of AI utilisation, with a trial involving 'HR potentials' while recognising room for further development. The primary focus appears to be on digitalizing and streamlining processes, which improves accessibility of documents and efficiency of work. Salus is also exploring opportunities in talent acquisition through external agencies and predictive testing. Furthermore, the HR team is contemplating the introduction of AI-driven education and training to assess employee competencies and enhance developmental prospects.

One notable aspect of the interview was the emphasis on effective communication. The HR department recognises that *"communication is key, and if you can communicate well, you can somehow minimise [employees'] fears"* (Salus-4) and resistance within the workforce. This aspect also extends to addressing potential security issues in the absence of robust regulations and incentives for AI adoption.

Additionally, the HR team emphasised AI's role in boosting employee motivation through career development opportunities and support for overwhelmed employees. The organisation's readiness to adapt to AI varies across different age groups within the workforce, with younger employees *"that are definitely more open [to new technologies]"* (Salus-4) compared to their more tenured coworkers. To encourage AI acceptance among older employees, HR considers tailored approaches, rewarding first adopters and promoting internal knowledge sharing. Tools like Teams and Mentimeter support interdepartmental collaboration, highlighting the role of human interaction in fostering creativity and innovation. To further foster collaboration and innovation culture Salus introduced idea management system, electronic tool through which employees can propose ideas which are being evaluated in rewarded.

3.6 Sales and marketing

The domains of sales and marketing operate as distinct departments, yet their roles are intricately interwoven, demanding close collaboration. The sales department mostly relies on QlikSense for analysing historical data and other existing technologies and mathematical models rather than utilising AI. Similarly, the marketing department is at the early stages of using AI, such as ChatGPT, but only on the individual level with internal documents or content creation ideas. *"We often find it useful when drafting an internal report, an article, a guide, maybe some starting points"* (Salus-6). Both believe in the company's IT department's expertise for future AI implementations. As explained by an employee from marketing, *"I also have high hopes that our IT department will be here to support us, to tell us what is also possible in this area ... what is not possible, what is interesting, then we see how we could integrate it within our processes"* (Salus-6).

The company encounters challenges due to the evolving nature of the pharma business, making predictions difficult. They face strict regulations in Slovenia, and financial benefits are limited due to small profit margins, exacerbated by restrictions on advertising prescription drugs. In sales, the issue stems from a lack of awareness of AI's potential, while a key reason for not adopting AI technologies is the required investment and uncertain financial returns.

Despite these challenges, both departments see potential in AI. Marketing is already planning on implementing Customer Relationship Management (CRM) and sees an opportunity in interactive screens and the assistance of robots at pharmacies. AI could also enhance their marketing campaigns through personalised targeting. In sales, they acknowledge that *"artificial intelligence is definitely the future ... I see applications in many areas: in sales integration, planning, we already help ourselves in purchasing"* (Salus-6).

Based on the interviews, Slovenian pharmaceutical wholesale distributors lag behind international companies regarding AI adoption in marketing and sales. Abroad, virtual robots are already used at pharmacies, and digital screens are common for customer interaction. Interviewee 6 expressed issues with robots in Slovenia: *"It is already a problem here for our regulation because deblistering is already an intervention in the medicinal product,"* therefore not allowed (Salus-6). The openness to AI adoption also varies between private and public pharmacies, with differences in their willingness to embrace these technological advancements.

3.7 Procurement

Salus demonstrated a strategic shift towards incorporating artificial intelligence for procurement, including order placement and creation. Collaborating closely with an AI solutions provider, they started a journey of tailoring the solution by programming and providing their invaluable data. The core of this transformation involved the creation of procurement orders driven by machine learning algorithms. *"It is the creation of procurement orders based on the assumption of planned sales, and this artificial intelligence, we call it machine learning, is made by the company BE-terna"* (Salus-8). Over two years, an advanced system was developed to predict sales trends and propose optimal procurement quantities at the individual product level. The implementation process included meticulous incorporation of user feedback, resulting in a highly optimised procurement AI system. The interviewee was clear about the expected implementation timeframe: *"AI system is a good tool; however, it takes time to put it in place; one year is definitely not enough"* (Salus-8).

This complex process involved considering variables such as inventory levels, sales statistics and supplier schedules and optimising logistical processes to ensure the right quantities were ordered. The transition to the AI-driven system was met with some initial scepticism, which was eventually overcome through training and user engagement. Despite the challenges, the system brought significant benefits, including substantial time savings for the procurement team and optimisation of inventory management.

These innovations not only streamlined their operations but also aligned them more closely with their core pharmaceutical business, enhancing efficiency and cost-effectiveness in the long run. *"I can only say that before, when this program did not exist, we had a stockholding of, on average, 34 days, but now we have a stockholding of about 30 or even less than 30 days, and that is already very noticeable in the four to five days of savings in stockholding"* (Salus-8).

While the system had achieved remarkable success, there was still untapped potential for further development, such as including the weather conditions, *"Today it is sunny, tomorrow it is rainy or a cool down is forecast in 3 days, but the system does not take that into account yet, so maybe it could be taken into account. Because when there is an external cold, there will be more colds, more illnesses, more sore throats and fevers, things like that, let's say, it doesn't take that into account yet"* (Salus-8). This highlights also the dynamic nature of AI in modern procurement practices.

3.8 Finance

In the finance department, they acknowledge AI's potential to fundamentally alter financial data processing and analysis, potentially reshaping the finance landscape. They see AI as a tool with which *"all these repetitive tasks would be reduced and that people would then do what has some added value"* (Salus-7). This shift aligns with the broader organisational goal of maximising efficiency and productivity.

A key discussion point focused on AI's role in document indexing. The department is actively exploring AI-powered systems to improve document management and reduce manual indexing and retrieval workloads. The overall sentiment is positive, with an emphasis on AI's reliability. *"Very reliable if taught right. Which means that the first person to process an invoice must be very precise"* (Salus-7). The potential for a 97 percent reliability rate demonstrates the department's commitment to maintaining high standards while leveraging automation.

As for challenges in AI implementation, interviewee 2 acknowledged that *"people then start to fear for their jobs ... and that is the general unwillingness of most people to accept change."* However, they firmly believe that *"that is something that can be communicated"* (Salus-2), and by showcasing the benefits, these reservations can be overcome. Moreover, the department is keen on identifying cost-saving opportunities, particularly at the EU level, where formatting issues present opportunities for streamlining financial processes in international business.

The importance of training and upskilling employees for the AI-powered future was also mentioned in the discussion. One-on-one coaching, internal knowledge sharing, and tailored training programs are actively employed to ensure employees can adapt to the changing landscape and leverage AI to its full potential.

Conclusion

The adoption of AI in the Slovenian wholesale industry is at 12 percent, showing a proactive approach to AI adoption compared to the EU. In Slovenia, these technologies are used for marketing and sales, optimising production processes, logistics, ICT security, and human resources management.

AI plays a crucial role in improving operational efficiency and delivering healthcare services in Salus Group. They use AI-driven inventory management systems to monitor pharmaceutical stock levels in real time and employ AI-powered data analytics. Salus Group's strategic goals include leveraging AI for demand forecasting, reducing inventory, and expanding into Central and Eastern Europe.

Through a series of interviews, it became evident that Salus has embarked on a transformative journey towards digitalisation and AI utilisation, with a strong emphasis on efficiency and optimisation. Salus has demonstrated a significant commitment to AI integration, but it is essential to note that the company is currently more inclined toward digitalisation techniques than specific AI applications. Nevertheless, their progressive stance in adopting AI, particularly in procurement and inventory management, represents a forward-thinking approach that positions them at the lead of industry advancements. Salus recognises AI's potential for streamlining processes, reducing costs, and enhancing the overall customer experience.

As the business landscape continues to evolve due to technological advancements, Salus's journey provides a valuable case study. It underscores the importance of adaptability and innovation in staying competitive and future-ready. The integration of AI in the wholesale medicine and medical equipment sector holds significant potential for driving operational efficiency and delivering enhanced value to customers. Salus is ambitious to offer valuable lessons and insights for other businesses seeking to embark on their AI-driven transformation journey, ultimately contributing to the continued evolution and optimisation of the industry.

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ARTIFICIAL INTELLIGENCE AT WORK: THE CURRENT AND FUTURE IMPACT ON WORKERS IN SLOVENIA

Introduction

AI poses exciting opportunities and difficulties as it develops, changing not just the nature of work but also the experiences of individuals who participate in it. For instance, previous studies have shown that perceptions of job security in an era of automation, as well as the degree to which AI is integrated into work processes, can have an impact on job satisfaction (Bhargava et al., 2021; Woods, 2021) and reduces the level of stress (Nazareno & Schiff, 2021). Studies have also shown that AI may dramatically improve overall work performance by automating monotonous activities, delivering data-driven insights, and facilitating more effective decision-making (Xu et al., 2023). This chapter explores how AI is transforming the workspace and affecting work activities in Slovenia by answering the following research questions: (1) How prevalent are AI technologies in the everyday work and lives of employees? (2) How do Slovenian workers perceive the current impact of AI on their daily work activities and conditions? (3) What are the expectations of Slovenian employees regarding the impact of AI on their future work?

The chapter begins with introducing the methodology, the sampling procedure, and the analysis process used for this research. Then, preliminary results are presented and related to previous literature, followed by an overview of the findings, connecting them to a broader framework. Lastly, a conclusion is drawn from the analysis of the obtained data and the literature overview.

1 Methodology

A quantitative approach was used to answer the research questions. Thus, a questionnaire developed by the OECD was employed, which was enhanced by incorporating Slovenian particularities. The questionnaire was created in 1ka. The survey was conducted between 25 May and 25 August 2023. The eligible respondents were workers aged 18 years and older, employed in the private or public sector in Slovenia.

Table 1. Sample characteristics

		Frequency	%
Gender	**Male**	192	44.6
	Female	238	55.4
Age	**Under 20 years old**	4	0.9
	21 to 40 years old	176	40.8
	41 to 60 years old	226	52.3
	More than 60 years old	26	6.0
Place of birth	**Born in Slovenia**	383	92.7
	Born elsewhere	30	7.3
Education	**Primary, Vocational and Secondary school**	124	30.0
	Higher vocational school and University degree	213	51.6
	Master's/Doctoral degree	76	18.4
Employment type	**Permanent employment**	325	85.7
	Fixed-term employment	54	14.3
Industry group	**Knowledge-intensive services (KIS)**	110	30.2
	Less knowledge-intensive services (LKIS)	63	17.3
	Manufacturing	31	8.5
	Public services	106	29.2
	Other	54	14.8
Sector	**Public**	149	38.8
	Private	211	55.0
	Self-employed	24	6.2

Source: Own work (2023).

The socio-demographic characteristics of the sample are presented in Table 1. Respondents came from five broadly defined industries (Eurostat, n.d.): (1) knowledge-intensive services (KIS) (i.e. Financial and insurance activities;

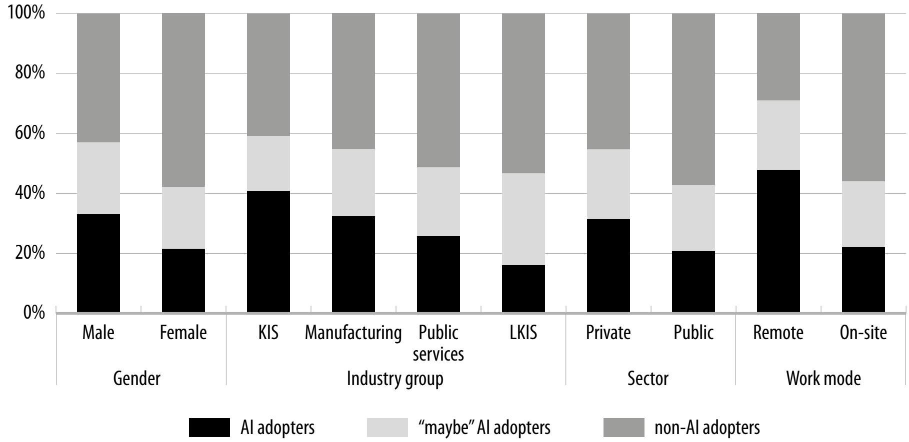
Telecommunications; Arts, entertainment and recreation; Professional, scientific and technical activities; Other miscellaneous business activities), (2) less knowledge-intensive services (LKIS) (i. e. Construction; Real estate; Trading; Transport and storage; Food service), (3) manufacturing, (4) public services (i. e. Health and social work; Education; Public administration and defence) and (5) other (i. e. Farming; Mining; Electricity, gas and steam supply; Water supply, sewerage and waste management).

A classification of AI adopters and non-AI adopters was made based on the reported AI usage in the company the respondents work at. They were divided into three categories: AI adopters (27 percent), 'maybe' AI adopters (22 percent), and non-AI adopters (51 percent). Using the Chi-squared test and subsequent analysis of Cramer's V statistic, adhering to Funder's classification criteria, statistically significant differences were found between the mentioned groups based on **gender, sector (private/public), industry group, and work mode (home/on-site)**. Interestingly, there were no statistically significant differences regarding age, education, or size of the company (measured in number of employees) and full- versus part-time employment.

The proportion of AI adopters is higher among **men**. Regarding industry, the highest percentage of AI adopters is in the **knowledge-intensive services (KIS)**, followed by manufacturing, public services, and lastly, less knowledge-intensive services (LKIS). Comparing the three groups of adopters based on sectors, AI adopters were most highly represented in the private sector. Lastly, analysis of the groups based on work mode (whether they work mostly from home or hybrid versus working on-site) revealed the higher proportion of AI adopters is among those that **work remotely or hybrid**. All differences, presented in Figure 1, are statistically significant.

These findings imply that (1) AI can facilitate tasks that do not require physical presence, making it relevant for knowledge-intensive industries where remote work is more feasible; (2) AI is particularly relevant in sectors where information, data analysis, and intellectual skills are paramount. It can enhance efficiency, accuracy, and productivity in industries that rely on data-driven decision-making, and (3) businesses are leading the way in incorporating AI technologies, which could be due to factors such as competitive pressure, profitability potential, or a greater capacity for investment compared to the public sector. However, it is important to remember that these implications are based on the given observations and may vary. To gain a deeper understanding, further research and analysis are needed to explore the underlying reasons and consequences of these trends.

Figure 1. Comparison of AI adopters and non-AI adopters



Source: Own work (2023); N = 364

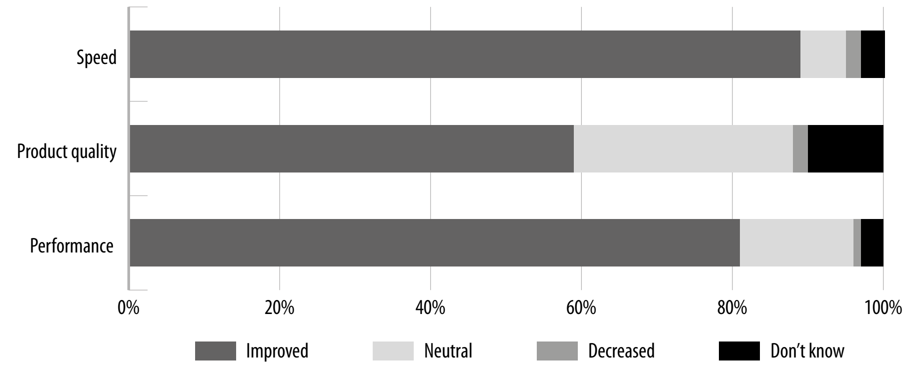
Interestingly, compared to a study by OECD (Lane et al., 2023), it was confirmed that AI adopters are more likely to be male; however, there were no statistically significant differences in age and education. In Austria, Canada, France, Germany, Ireland, the United Kingdom, and the United States, AI users are more likely to be younger (aged under 50) and more educated than non-adopters (Lane et al., 2023). This deviation might be due to the smaller sample size or different sample structure. However, further research is needed to look into the matter more closely and further explore the underlying factors that contribute to these variations.

2 Preliminary results on impacts of AI on workers in Slovenia

2.1 Impact of AI on individual productivity

The influence of AI on individual productivity in Slovenian companies can be shown using three important indicators: job completion times, product quality and performance. Respondents answered questions about the change in a certain indicator on a Likert scale (1 = high increase, 5 = high decrease).

Figure 2. Impact of AI implementation on speed, product quality and performance (in %)



Source: Own work (2023); N = 53.

One of the primary reasons businesses use AI is to reduce the time required to execute specific tasks and to make operations more efficient. This enhancement is especially sought in corporate settings, where giving meaningful data to stakeholders on time is critical. According to predictions, AI is expected to replace traditional forecasting methods in 50 percent of such businesses (Hagerup, 2023). This research shows that AI adoption has resulted in a significant and beneficial shift in work speed across all industrial groups studied (Figure 2). However, the biggest rise in work pace was observed in knowledge-intensive services, whereas all other groups were less affected. The impact of AI on speed is underscored by the fact that 89 percent of respondents reported an increase in their work speed, whereas a mere two percent indicated a decrease. These findings show the potential of AI as a driver of enhanced labour efficiency.

AI can also contribute to more efficient solutions that help clients reach their goals, which is especially essential in manufacturing since it might affect the quantity of waste created during the operation. Workers overwhelmingly reported a significant improvement in product quality following the implementation of AI, with 59 percent indicating an enhancement and only two percent noting a reduction. Manufacturing and less knowledge-intensive services reported the greatest improvement. Positive change was also observed in the other three groups, though not to the same extent.

Finally, AI is being researched and deployed so widely because people believe it can increase **overall performance** by 66 percent on average (Nielsen, 2023). Within Slovenian workers, there is significant proof to infer that AI implementation improved performance. Among the AI users, 81 percent reported improved performance, while only one percent reported a deterioration. The greatest improvement was found in the other industry category (predominantly utilities), with a lesser gain noted in manufacturing and less knowledge-intensive services. The smallest rise in reported performance improvement was found in public services (education and health). The respondents were also asked to rate the potential change in performance when using AI. In the areas of fraud detection and legal matters, the usage of AI has helped improve performance enormously. It has also benefited HR greatly and brought some enhancement of the performance in the areas of data analytics, risk management, trading and investments, administrative matters and reporting.

2.2 Impact of AI on working conditions

As businesses move towards increased automation, it is crucial to explore how this new wave of technology is not just displacing jobs but also enriching the work experience for employees (IndustryTrends, 2023). It was of considerable interest to investigate the influence of various factors on work-related well-being and job satisfaction. In the questionnaire, the term ‘job satisfaction’ encompasses automation of mundane tasks, setting the ‘work-life balance’ as well as advanced workforce analytics. Job satisfaction after implementing AI reportedly increased the most in manufacturing activities and the Other industries (e.g., Mining; Electricity; Gas and steam supply; Water supply, sewerage and waste management), while the rest experienced just a slight increase, the smallest visible was in the less knowledge-intensive services. This conclusion could be connected with the fact that AI removes a burden – especially with repetitive tasks – they are potentially automated, so the workers are more focused on the creative, meaningful tasks of their work, human connections, high-level decision making and more. AI also offers real-time analytics, allowing timely interventions and adjustments to improve job satisfaction and engagement (IndustryTrends, 2023). Regarding the work-life balance, using remote working tools entitled by AI helps set boundaries that respect personal time, therefore enhancing it. Approximately 38 percent of respondents indicated a favourable shift, showing AI’s potential to improve worker satisfaction, while 6 percent saw a reduction in satisfaction.

AI also has a significant influence on psychological **well-being**. Although this influence is statistically significant, all the industries noticed just a slight positive change, the highest being in less knowledge-intensive services in both areas. Some businesses in those services have already begun using AI to perform all the dangerous, risky tasks that come with hands-on work. These tasks, if resulting in high near-miss or incident rates, cost businesses hundreds of thousands of dollars annually (Strick, 2023). This positive change could also be connected to using Robotic Process Automation (RPA) to take on tedious, repetitive tasks and improve safety and predictive maintenance, which results in a better mood for the employees and employers.

Regarding AI's effect on **health and safety**, 15 percent of respondents perceive a significant improvement. Similarly, 26 percent observed a significant gain in their psychological health. These replies illustrate AI's potential benefits in improving both physical and mental health. However, 7 percent reported a reduction in both areas. The occurrence of diverse answers highlights the complexities of AI's influence on people's overall well-being, necessitating a complete strategy for adoption and support.

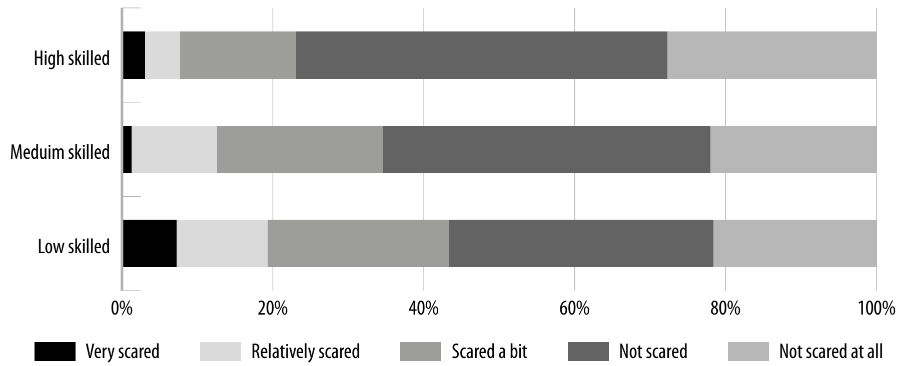
Lastly, survey results show that AI usage has not resulted in a major shift in **management fairness**. The biggest difference is noticeable between manufacturing and other industries, which experienced an improvement in fairness towards the employees. On the other hand, the employees working in public services and less knowledge-intensive services experienced a slight decrease in management fairness, probably due to a decrease in 'personal contact' with the management. Also, because of the growth of AI and its contributions and capabilities, managers have leverage over the employees since they can be replaced by AI to some extent. To conclude, 75 percent of respondents indicated no change, showing that AI installation has had little to no influence on the perceived fairness of management treatment.

2.3 Expectations for the future impact of AI

The ongoing impact of technological advancements on employment has historically stimulated feelings of insecurity and anxiety among the workforce (Atkinson & Wu, 2017). Levy and Murnane (2003) researched that jobs that are more at risk because of technological development are the ones that require fewer skills in comparison to the ones that require highly skilled personnel.

People have different perceptions of how AI will **affect their jobs in the next two and ten years**. They responded to a question on a Likert scale (1 = extremely concerned about their job, 5 = not concerned at all). Answers were compared based on the skill level of respondents (low-skilled, medium-skilled and high-skilled). Significant evidence shows workers are not scared to lose their jobs in the next two years. Very similar answers from all three groups can be observed, which leads to the conclusion that people do not think their skills will influence their employment in the next two years. On the other hand, this is not the case with the question about expectations in ten years. Although respondents still do not seem scared of losing their jobs because of AI in the future, there are now visible distinctions between skill groups (Figure 3). With highly skilled people being the least afraid and low-skilled workers being the most afraid, significant distinctions can be seen between the expectations of differently skilled personnel.

Figure 3. Expectations about employment in ten years



Source: Own work (2023); N = 308.

These observations lead to two conclusions regarding people's expectations about employment. To begin with, people are not scared that AI will replace them in their workplace in the next ten years. Secondly, workers think that the more AI develops, the more important it will be to have higher education to keep their jobs. This conclusion also confirms that people agree with Levy and Murnane's (2003) assertion that low-skilled workers are more likely to lose their employment due to technological advancement, which scares them. People believe AI will continue to advance and influence the workplace, which is why all three groups gave more negative answers when asked about expectations in ten years.

AI has already impacted some employees in Slovenia; nevertheless, this is only the beginning, and the transformation will continue. There are conflicting perspectives on the impact of AI throughout the world, and they differ depending on what is compared. There are some fairly optimistic hopes for AI adoption by businesses. People expect AI to close the talent gap, enhance hiring methods, and break down barriers in the workplace through adaptable work environments (Bryant, 2023). On the other hand, there is significant scepticism regarding pay expectations based on experiences in earlier years and decades (Kelly, 2021).

Expectations for two factors were examined, **labour conditions and earnings**, and it was discovered that they indeed differ. People responded to questions regarding their feelings about these issues, indicating whether they were hopeful or pessimistic. The responses show that individuals are optimistic about AI's impact on future working conditions. However, there is significant doubt regarding the earnings because the negative responses mean that workers expect their wages to decrease. This study of Slovenian workers supported conventional assumptions about pay and working conditions.

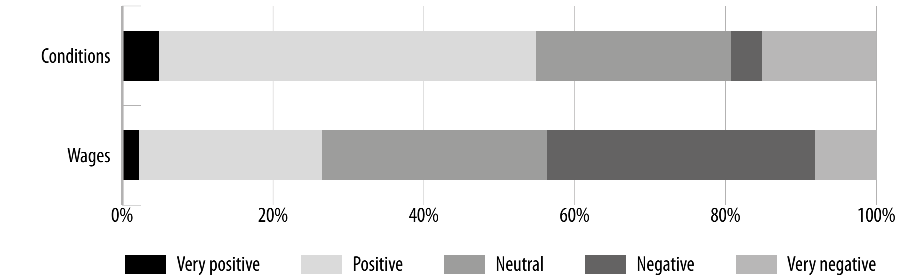
3 How is AI changing the nature of work?

The findings reveal significant **improvements in productivity and working conditions** for Slovenian workers due to AI adoption. Regarding productivity, AI has led to substantial reductions in job completion times across all industry groups, especially in knowledge-intensive services. Overall work performance has improved, with the category of Other industries (utilities) experiencing the most significant enhancement. Notable advancements in product quality were also observed, with manufacturing and less knowledge-intensive services benefiting the most. Regarding working conditions, AI has positively impacted job satisfaction, particularly in manufacturing and the Other sector. It has also improved health and safety, as well as psychological well-being, notably in less knowledge-intensive services. Furthermore, AI has contributed to enhanced management fairness, with manufacturing and Other industries showing the most positive effects.

Regarding Slovenian workers' **expectations for the future**, the findings show they **exhibit a range of expectations, with varying degrees of optimism and pessimism in different aspects**. Expectations about their employment show that Slovenian workers, regardless of their skill levels, are not afraid of job loss within the next two years. However, there is a slightly more pessimistic outlook when considering a longer timeframe of the next ten years, particularly among low-skilled individuals. Concerning expectations of the changes in working conditions, employees express optimism about the future impact of AI.

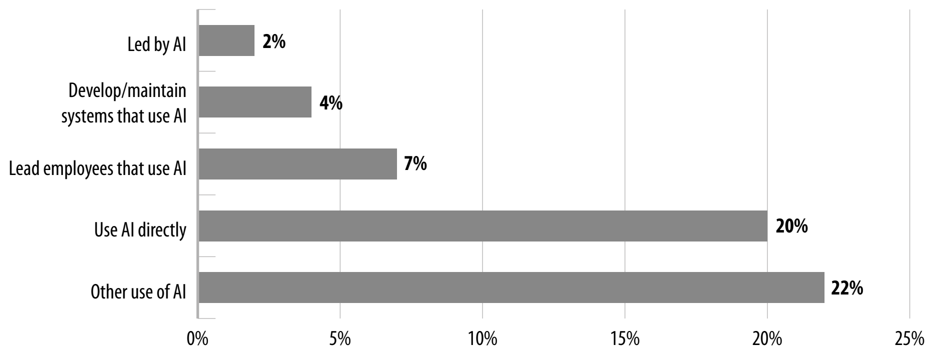
However, regarding wages, workers tend to be pessimistic about the influence of AI on their future earnings (Figure 4). This pessimism underscores the need for careful consideration and strategic planning to address potential concerns related to income stability in the era of AI.

Figure 4. Expectations about working conditions and wages in the future



Source: Own work (2023); N = 364..

Figure 5. Types of use of AI at work



Source: Own work (2023); N = 364.

The analysis shows that Slovenian workers are not alien to AI technologies. In the subgroup of the respondents that use AI at work, most answered that they use it in other not specified ways, followed closely by those who use it directly. Among respondents, 26 percent lead employees that use AI, 16 percent develop/maintain systems that use it, and the least are led by AI, as shown in Figure 5.

Despite its recent rise in popularity, **more than half of respondents do not use AI** (52 percent do not use it at work, and 55 percent do not use it privately). This observation leaves a big window of opportunity for future implementation of AI technologies and a field yet to be explored since expectations and opinions on AI's use can change once more people are using it.

These findings provide valuable insights for policymakers and organisations to navigate the evolving landscape of AI, ensuring equitable and ethical integration to continue benefiting the workforce. Additionally, more research is needed to explore AI's specific effects on different industries and monitor its long-term implications as AI continues to evolve. Comparing Slovenian workers to the global dataset reveals interesting findings. Like workers in Germany and Austria, Slovenian workers tend to have a somewhat neutral, yet slightly positive, outlook. However, when it comes to AI's impact on wages, Slovenian workers stand out as they anticipate a negative effect. This comparison highlights diverse views across countries on the implications of AI for working conditions and compensation (Domadenik Muren et al., 2023).

Slovenian, British, and German workers show limited concern about AI-induced job loss in both the short (two years) and long term (ten years), maintaining a relatively optimistic outlook compared to other nations (Table 2). This shared perspective suggests a consistent view of AI's impact on future employment.

Table 2. Comparison of short- and long-term expectations on employment by country (average answer)*

	Job loss in 2 years	Job loss in 10 years
Slovenia	4.03	3.72
UK	4.00	3.70
Germany	3.93	3.69
Canada	3.88	3.65
France	3.76	3.63
Austria	3.68	3.54
USA	3.69	3.51
Ireland	3.58	3.32

*1 = very worried, 5 = not worried at all.

Source: Own work (2023); N = 338.

Because AI has rapidly gained popularity in recent years, no one knows how it will influence employment as the technology advances. There is a lot of concern about AI, not only because of potential job losses in the future but also because of privacy, fear of losing control, and other factors. There is currently no policy in Slovenia to govern the negative effects of AI; however, the

EU is already well on its way to passing the world's first AI law, which would also impact Slovenia. The main purpose of this regulation is to make AI use in the EU safe, transparent, traceable, non-discriminatory, and environmentally beneficial. The law will also assess the levels of risk posed by AI and categorise it as unacceptable, high, or limited risk. For most people, AI is still a new concept. Since it is evolving swiftly, it is critical to regulate it soon enough to protect people and, as a result, attract them to use it comfortably, which is the only way to reach its full potential (European Parliament, 2023).

Conclusion

In Slovenia, AI adoption is prevalent among male workers, especially in knowledge-intensive services (KIS) and the private sector, particularly in remote or hybrid work setups. AI significantly accelerates work speed, particularly in KIS, and enhances product quality, most notably in manufacturing and less knowledge-intensive services. AI consistently improves employee performance, mostly in Other industries (utilities), and positively influences job satisfaction and well-being. However, slight fairness concerns exist in public and less knowledge-intensive services.

Regarding future expectations, highly skilled workers are optimistic, while low-skilled workers are more apprehensive about their future wages, thus contrasting with the optimism in other countries. On the contrary, compared to other nations, they are the least concerned about job loss due to AI usage in both the short (two years) and long term (ten years). These findings guide policymakers and organisations aiming for equitable AI integration to benefit the workforce. Slovenian workers maintain a generally neutral stance on AI's daily work impact, though the influence on future wages remains uncertain. Nevertheless, AI promises a more efficient and creative labour market by automating tasks and enhancing human decision-making.

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WORKERS IN TRANSITION: THE IMPACT OF ARTIFICIAL INTELLIGENCE IN OECD COUNTRIES

Introduction

Artificial intelligence (AI) will potentially impact 300 million jobs. Additionally, it is predicted that 85 million jobs will be replaced and 97 million new jobs will be created by AI by 2025 (Silver, 2023). These predictions vividly portray the transformative power and potential of AI.

This chapter conducts a comparative study in seven OECD countries (Austria, Canada, France, Germany, Ireland, United Kingdom, and the United States) based on 2022 Microdata from the OECD worker survey on the impact of AI on the workplace (OECD, 2022), to examine workers' perceptions of the current and future impact of AI. It examines the individual and workplace determinants influencing AI adoption, highlighting country-specific differences. In addition, the study extends its analysis to the key sectors of finance and insurance and manufacturing to describe the differential impact of AI transformation. The research questions this study aims to answer are: (1) What factors contribute to the variation in AI adoption and usage rates among studied OECD countries? (2) How does the impact of AI on working conditions and employment collectively influence the adoption and usage rates of AI technologies in different OECD countries? (3) What are the long-term expectations regarding AI's impact on labour markets in OECD countries, including job creation, job displacement, and shifts in employment stability, and how can countries prepare to maximise the benefits and minimise the risks? Finally, the study will allow for a comparison between OECD countries and Slovenia on various workplace-related aspects discussed in this chapter and provide valuable insights for Slovenian companies and policymakers (Domadenik Muren et al., 2023).

The chapter begins with a brief overview of relevant theory, followed by a methodology section that provides insights into the sample and research methods. The final section is devoted to the comparative analysis across OECD countries, examining dimensions such as familiarity with AI, adoption, use, impact on working conditions and employment, and expectations about the future impact of AI. The chapter concludes with a summary of the main findings and their correspondence to the research questions.

1 Effects of AI technologies on employment, wages and GDP growth

The impact of AI on the labour market is multifaceted. While concerns about job losses persist, companies using AI to innovate are poised to expand their workforce. Early adopters focusing on innovation are well-positioned to grow, driving employment (Bughin, 2018). According to the McKinsey Global Institute, AI could lead to a decline in employment by 2030, though not on a large scale (Manyika & Sneader, 2018). In the long term, the revival of economic conditions will hinge on how AI adoption influences income distribution. If advances in AI technology don't lead to increased wages, the diminishing share of labor income in the GDP will lead to reduced overall demand. This, in turn, would hamper both the current and potential growth of the economy and hinder the creation of new jobs, causing further delays in boosting productivity and GDP growth (Gries and Naudé in 2021).

Empirical studies show that AI-enabled automation in the past few years has been associated with an increase in employment, especially in occupations with a higher share of skilled workers. The relationship between AI adoption and wages is negative and not significant. The impact of software exposure on employment trends is heterogeneous across European countries and has no significant impact on wages (Albanesi et al., 2023).

There is a strong inverse relationship between the importance of AI expertise and routine skills in employment, with AI expertise being important in certain areas such as computer science, IT management, and data analysis (Lane et al, 2023). About 30 percent of Japanese workers, especially younger, non-permanent, clerical, and manufacturing employees, are concerned about job loss due to AI and robotics. Individuals with a background in science and engineering may be less concerned about job displacement by AI and robotics, as these technologies can complement their adaptable high-level skills. In contrast, automation makes professions requiring specialised human-intensive service-related skills, such as childcare, medical care, and education, less easily replaceable (Masayuki, 2017).

The impact of AI on the labour market should be observed through task substitution, complementarity, and expansion. AI algorithms have improved task matching and workflow efficiency. AI helps with task classification and allows employees to focus on challenging tasks while performing complex process management tasks (Donepudi et al., 2020). Manual jobs still account for 19 percent of the workforce in the OECD. AI and robotics will replace 30 percent of routine knowledge work by 2025. Teaching, law, medicine, management, and the arts will more likely be transformed than eliminated. Computerisation and also the wide accessibility of generative AI technologies may lead to eliminating also creative jobs, upgrading some, and creating new ones. Emerging industries such as e-commerce and alternative energy could create new jobs. The technological revolution is expected to create numerous job opportunities and a global industry worth trillions of dollars (Halal et al., 2016).

Between 2012 and 2018, job postings for software-related AI skills increased by about 30 percent. Software engineering and development skills are less important, while Natural Language Processing and Deep Learning skills are gaining importance. AI-related jobs in all countries require Big Data skills. Skills in communication, problem-solving, creativity, and teamwork are becoming more important for AI-related jobs. Certain skills, such as cluster analysis and machine vision, are suddenly in high demand. AI-related jobs can be found in a variety of occupations and different sectors of the economy (Squicciarini & Nachtigall, 2021).

Wide applicability of AI technologies will introduce intriguing dynamics into global economies, but these changes may not necessarily guarantee improved prosperity in the future. If investments in AI-driven process innovation lead to a simultaneous decline in product innovation in traditional, non-AI sectors, economic growth would be adversely affected. Wages would stagnate in response to weaker GDP growth, with the objective of preserving employment levels. Empirical and theoretical evidence suggests that this phenomenon might be responsible for the coexistence of high employment rates, stagnant wages, and sluggish productivity and GDP growth despite the progress in AI technology (Gries and Naudé, 2021).

2 Research methodology

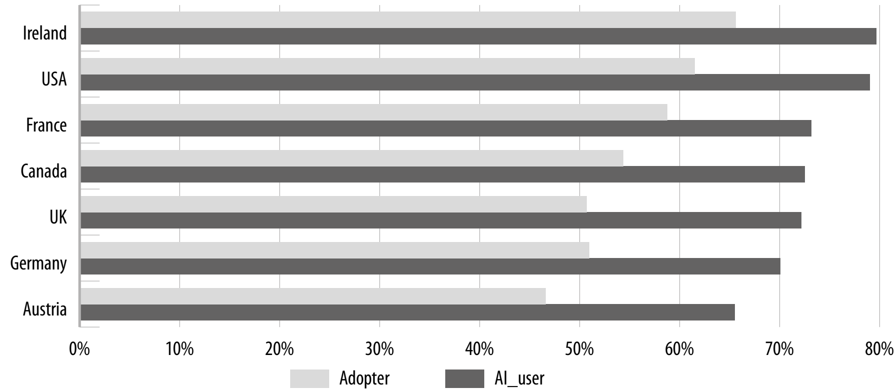
The analysis is based on 2022 Microdata from the OECD worker survey on the impact of AI on the workplace (OECD, 2022). It includes 5,334 workers in the manufacturing and financial sectors across Austria, Canada, France, Germany, Ireland, the United Kingdom, and the United States. Males represented 58 percent, while females accounted for 42 percent of all participants. A little more than half of the respondents, precisely 54 percent, had at least a university degree. From every country, there were between 700 and 850 respondents, except for Ireland, which had less than 450 respondents. They managed to achieve a balanced mix of people from the financial and insurance sector (48 percent) and the manufacturing sector (52 percent). Most respondents (44 percent) work in companies with 500 workers or more, regardless of the country they came from. Unsurprisingly, the majority (94 percent) had heard of AI before and at least roughly knew what it meant (91 percent). Table A1 in the Appendix provides additional sample details.

3 Results

3.1 Factors influencing AI adoption and usage rates across OECD countries

AI adoption represents a critical step on the AI journey for organisations. Respondents were divided into **'adopters'** and **'non-adopters'** based on whether the company they work for was adopting AI technology. Austria, Ireland, and the USA showed interesting trends in AI adoption. Austria exhibited a comparatively lower rate of AI adoption, while Ireland and the USA demonstrated higher prevalence (Figure 1). On the other hand, when examining individuals' engagement with AI, respondents were divided into two categories: **'AI users'** –those who actively engage with AI in various capacities (e.g., work with AI, manage AI employees, develop/maintain AI, are managed by AI, or interact with AI in other ways), and **'AI non-users'** – those who do not engage with AI. The Chi-square test for usage revealed almost the same results as for adoption – Austria had a lower AI usage rate, while Ireland and the USA reported higher rates (Figure 1).

Figure 1. AI-adopting companies and AI users, in percent of respondents



Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers; N = 5,334.

The differences in AI adoption and usage can be explained by higher investment in digitalisation and AI technologies in Ireland and the USA with respect to EU countries. In the USA, the level of AI investment from 2018 to 2020 was twice as large as in the EU and amounted to 64.4 EUR per capita in 2020, significantly higher if compared to 24 EUR per capita in EU-27 (Evas et al., 2022). The DESI index, an important measure of a country's digital readiness, was 62.7 in Ireland, compared to 54.7 in Austria and 52.9 in Germany (European Commission, 2023). This discrepancy suggests a more favourable environment for digital adoption in Ireland and offers a compelling explanation for the different rates of AI adoption/use in these countries.

Based on the analysis, industry specifics also impact AI adoption. In the finance and insurance sector, 63 percent of companies are equipped with AI, while only 47 percent use this technology in the manufacturing sector. In addition, there tend to be more AI non-users in the manufacturing sector. Notably, the Austrian sample is the only country sample among the countries studied where a higher percentage of employees work in the manufacturing sector than in the finance and insurance sector, further reinforcing the link between industry specifics and trends in AI adoption and usage.

Finally, as the analysis revealed, the comparatively lower level of respondents' education in the Austrian sample was closely associated with a higher prevalence of AI non-users. Also, more educated respondents in Austria showed a lower propensity to engage with AI if compared with counterparts in other countries. However, these findings should be interpreted with caution as we were not able to control for firm-level specific factors that influence the use of AI technologies in the firms.

3.2 AI's impact on employment and working conditions

In the survey, questions about the impact of AI on individuals' performance and working conditions were directed exclusively to workers who actually use AI, manage workers who work with AI, develop or maintain AI or is managed by AI. Across all performance and working condition indicators under consideration, those who use AI were more than four times as likely to report improvements resulting from AI usage than to indicate any deteriorations (Lane et al, 2023). In both studied industries, finance and manufacturing, over half of AI users noted enhancements in their performance, job satisfaction, and mental well-being. However, the disparity between these sectors became more pronounced when assessing the impact on physical health and safety. In manufacturing, 65% of respondents reported that AI had positively impacted their physical well-being and safety, compared to just under half of workers in the finance sector. When it came to evaluating how fairly their managers or supervisors treated them due to AI, workers displayed a somewhat less enthusiastic response, although the sentiment remained significantly more positive than negative (Lane et al, 2023). While displaying an overall positive outlook regarding the influence of AI on their individual performance and working conditions, workers who actively engage with AI, presumably experiencing the most direct interaction, tended to be less optimistic about AI's impact compared to those overseeing workers utilizing AI in the manufacturing sector or those engaged in AI development and maintenance within the finance sector. Among these groups, workers directly working with AI were most inclined to affirm that AI had enhanced their physical health and safety, and they were the second most likely to acknowledge AI's positive effect on their performance (Lane et al, 2021). Significant variations were observed among various countries, and these differences were tested using non-parametric Kruskall-Wallis test.

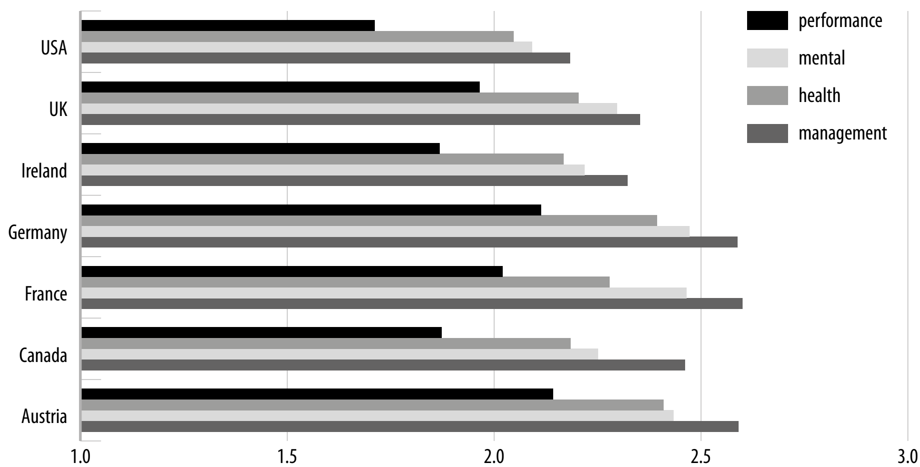
The impact of AI on employment is perceived differently across countries, particularly in the USA and Ireland, where 27 percent and 30 percent of respondents, respectively, said they knew people in their company or industry who had lost their jobs because of AI. A similar trend emerged among those knowing people who had to switch jobs within their industry, with both countries surpassing 30 percent. Given the USA and Ireland's leading positions in AI adoption, it is logical to expect that a significant number of individuals in these countries would experience job losses, highlighting how AI adoption is reshaping the labour landscape.

Job performance. Differences in perceptions of the impact of AI on job performance are particularly evident in a comparison between the USA, Austria, Ireland, and Germany (Figure 2). In the USA (1.71) and Ireland (1.87), AI has improved job performance a lot in the eyes of the respondents. On the other hand, in Austria (2.14) and Germany (2.11), AI has a moderately positive impact on job performance. Even though the general impact of AI on performance is positive, the USA and Ireland are more optimistic.

Workplace health and safety. Concerning the impact of AI on health and safety in the workplace, there are clear differences between Austria and the USA and between Germany and the USA (Figure 2). Austrian respondents (2.41) have a moderately positive view of the impact, indicating a slight improvement. In the USA (2.05), the perception is even more favourable. A similar pattern emerges when comparing Germany and the USA, with German respondents (2.39) reporting a moderately positive impact, while perceptions in the USA (2.05) are even more optimistic.

Mental well-being. When examining how AI affects mental health and well-being at work, Germany stands out as the least positive country (2.47), perceiving that AI has moderately improved mental health and well-being. On the other hand, in the USA (2.09) and Ireland (2.22), respondents have a more positive view of AI's impact on mental well-being (Figure 2).

Figure 2. Mean ratings of AI's impact on working conditions among AI users across countries (1=improved a lot, 5=worsened a lot)



Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers; N = 2,029.

Fair treatment by managers. The USA (2.18) stands out with a relatively positive perception, suggesting that AI has a moderately positive impact on managers' treatment of employees. This result contrasts with France (2.60) and Germany (2.59), where respondents report a more neutral view of AI's influence on fair treatment by managers (Figure 2).

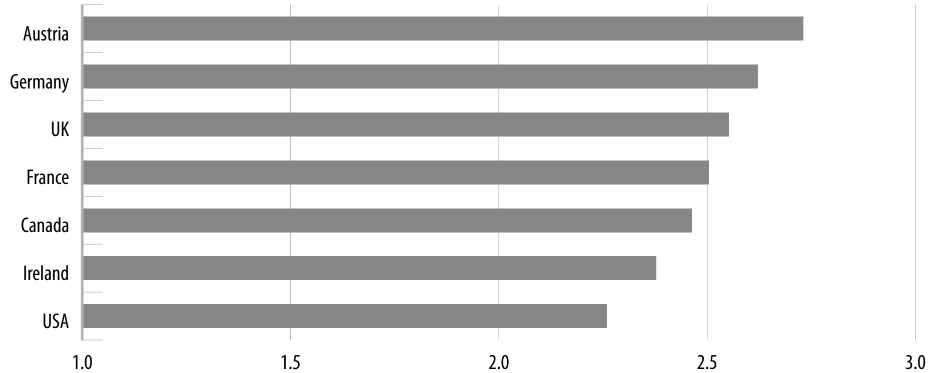
The impact of AI on the workplace is viewed very differently by AI users. The USA and Ireland are particularly positive, believing in improvements in job performance, health and mental well-being. Germany, Austria and France, on the other hand, are more cautious or neutral. Again, higher AI adoption and usage correlates with more positive perceptions of AI's impact on working conditions. In the analysis, despite the higher rates of redundancies and job changes reported in the questionnaire, both the USA and Ireland maintain a positive outlook, emphasising the value of AI technology and its perceived potential over risks.

3.3 AI's long-term impact on the labour market: workers, wages, job loss

The present effects of AI technology adoption on employment in the finance and manufacturing sectors appear to be relatively balanced. In finance, a higher proportion of workers (20 percent) acknowledged being aware of potential job losses, and 29 percent anticipated job changes within their companies, in contrast to their counterparts in manufacturing. These findings align with the results of the employer survey, where employers in the finance sector were more inclined to report a decline in overall employment as compared to those in manufacturing. This implies that AI technologies in the financial sector may have a higher tendency to replace labour (Lane et al, 2023).

The mean scores of **AI's impact on workers** ten years from now indicate relatively cautious stances and more neutral views taken by Germany (2.62) and Austria (2.73), the countries with long manufacturing tradition. In contrast, the USA (2.26) and Ireland (2.38) hold more optimistic views, expecting a more positive impact (Figure 3).

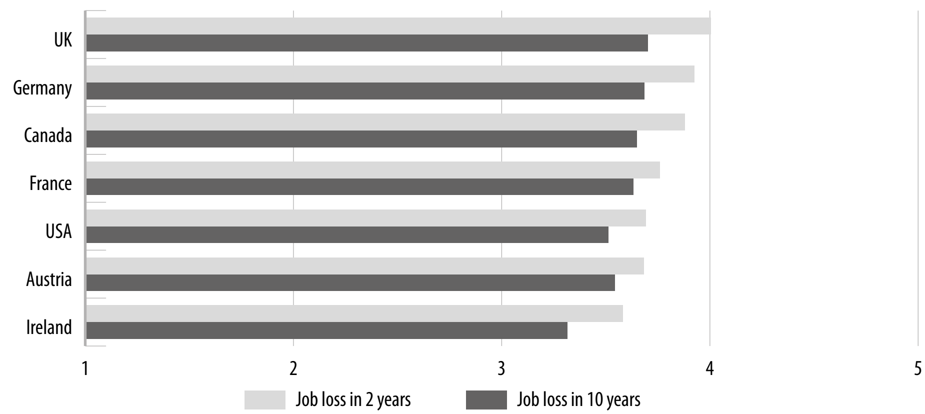
Figure 3. Mean anticipated impact of AI on workers by country (1 = very positive, 5 = very negative)



Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers; N = 5,334.

Within the finance sector, 19 percent of workers expressed significant concerns, being either extremely or very worried about **potential job loss due to AI in the upcoming two years**, while a majority of 46 percent reported having no worries at all. In the manufacturing sector, the numbers were slightly lower, with 14 percent expressing extreme or high levels of concern, and 50 percent expressing no worries about AI-induced job loss. The impact of AI on job losses over the next two years is particularly pronounced in Ireland (3.58) and Austria (3.68), reflecting relatively high levels of concern. In contrast, countries such as Germany (3.93) and the UK (4.01) show lower levels of concern (Figure 4).

Figure 4. Mean anticipated impact of AI on job losses in two years and ten years by country (1 = very concerned, 5 = not concerned at all)

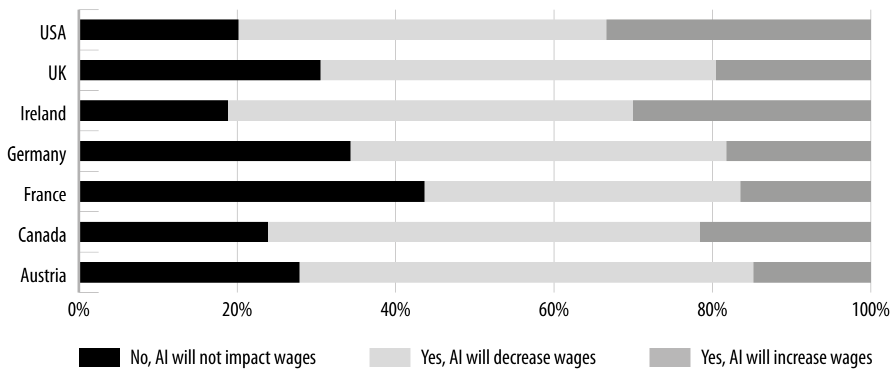


Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers; N = 5,065.

Comparing the outlook for job losses due to AI over a period of two and ten years, a trend toward slightly decreasing optimism can be observed in all countries (Figure 4). The UK (3.70) and Germany (3.69) remain more optimistic, while Ireland (3.32), the USA (3.51) and Austria (3.54) are more cautious regarding this impact. The difference in perception of potential job losses in two industries remains consistent over these two periods, with the finance and insurance sector generally showing greater unease than the manufacturing sector in most countries. This observation confirms the literature overview indicating that the labour market may be negatively impacted by AI, with job losses being a major concern (Bughin, 2018).

Interestingly, within both sectors, individuals who actively use AI technology exhibited greater concern regarding potential job loss in the coming years compared to those who do not use AI. The underlying rationale for this counterintuitive discovery could be that non-users do not anticipate incorporating AI into their work within the next decade, thus expecting reduced exposure to its effects. Alternatively, it is possible that AI users possess a deeper understanding of technology and are more cognizant of its potential for future automation (Lane et al, 2023).

Figure 5. Mean anticipated impact of AI on wages by country



Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers; N = 4,371.

The impact of AI on wages within the sector over the next ten years varies significantly, particularly between Austria, the USA, and Ireland. Austria is relatively negative, with 57 percent of people indicating that wages will decrease due to AI. In contrast, the USA (33 percent) and Ireland (30 percent) stand out as countries with the highest percentage of people indicating that AI will have a positive impact on wages, i.e. wages will increase (Figure 5). Nonetheless, individuals who actively utilize AI technology were more inclined than non-users to express their expectations that AI would lead to wage increases in their respective sectors over the next decade. This optimistic perspective from AI users poses a challenge when considered alongside their concerns about job stability. One plausible explanation is that AI users anticipate that, while AI may indeed result in job displacement, those who remain in the workforce will reap benefits from the technology, potentially resulting in higher wages (Lane et al, 2023).

This research has revealed a distinct industry variation in wage expectations, with the finance and insurance sector being less pessimistic. On top of that, Austrian manufacturing proved to be the most pessimistic, with a mean score of 2.43. It is worth noting that Germany is the only country where the finance and insurance sector is more pessimistic than the manufacturing sector regarding wages, which might be due to a substantially high number of work councils and trade unions in manufacturing.

Long-term expectations regarding the impact of AI on job losses, wages, and working conditions present challenges characterised by potential disruption and change. Addressing these challenges requires a multifaceted approach at the country level. Investment in adaptive education and upskilling programs is critical. Strong labour market institutions and a framework for collective bargaining can foster the creation of quality jobs, especially in less segregated labour markets. Governments and regulatory bodies must proactively update legislation to protect workers' rights in the evolving AI-driven labour landscape and support increasing share of labour income in GDP. In addition, detailed data collection on AI's sectoral and demographic impacts is critical for evidence-based policymaking (Deshpande et al., 2021). Finally, consistent with the literature, companies that use AI for innovation are likely to expand their workforce, mitigating concerns about job loss (Bughin, 2018) although we should be aware also of negative effect on AI-induced process innovation on standard, non-AI, product innovation (Gries & Naudé, 2021).

Conclusion

The impact of AI on work will be profound. Key factors that influence the adoption and use of AI have been uncovered by analysing real-world data. Economic indicators such as GDP per capita and digital readiness play a critical role in AI adoption. Countries with robust economies and higher DESI scores tend to invest more in AI technologies, driving transformative progress. In addition, industry specifics influence adoption trends, with the finance and insurance sector leading the way in AI integration. A positive correlation between higher education levels and AI engagement is also evident. Countries with high rates of AI adoption and use are more optimistic about its impact on working conditions and have optimistic expectations for the future. Ireland and the United States lead the way.

Slovenian respondents are in line with the general OECD sentiment on the impact of AI on working conditions, which is rather positive. The impact of AI on work performance is viewed positively in all countries. Like in Austria and Germany, Slovenian workers see modest improvements in workplace health, safety, and mental well-being. Finally, Slovenian respondents see no impact of AI on fair treatment by managers, as is the case in Germany and France. However, when it comes to perceptions of wages in the future, Slovenia, like Austria, is cautious and differs from the optimism expressed in Ireland and the USA. Slovenia, Germany, and the UK are less pessimistic about future job losses, underscoring a shared belief that investment in upskilling and reskilling will be paramount as AI advances (Domadenik Muren et al., 2023).

For nations and policymakers, these findings represent a critical turning point. Investing in adaptive education and upskilling programs is essential. Strengthening labour market institutions, promoting collective bargaining, and ensuring responsible corporate engagement are cornerstones for navigating this transformative era. Data-driven policies and actions by governments and regulatory bodies to protect workers' rights and privacy are important components of moving toward a future where AI will positively impact workers.

Companies have a huge responsibility in this time of change. They can leverage AI for exponential growth. However, it is critical to recognise a fundamental truth: The heart of any business lies in its people. A recent study by the United Nations' International Labour Organization (ILO) reports that AI will not replace jobs but transform them (Sharma, 2023). With prudent management, this transformation promises a future where both machines and people thrive in harmonious synergy, charting a course for boundless progress and prosperity.

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Appendix

Table A1. Basic characteristics of selected OECD countries by gender, education, sector, firm size and familiarity with AI

Respondents		Austria	Canada	France	Germany	Ireland	UK	USA	Total
Gender	**Female**	42%	43%	36%	40%	52%	43%	44%	42%
	Male	58%	57%	64%	60%	48%	57%	56%	58%
Education	**Less than graduate**	50%	39%	37%	53%	27%	53%	56%	46%
	Graduate or higher	50%	61%	63%	47%	73%	47%	44%	54%
Sector	**Finance and insurance**	43%	50%	49%	49%	47%	49%	49%	48%
	Manufacturing	57%	50%	51%	51%	53%	52%	51%	52%
Familiarity with AI	**No**	6%	5%	8%	3%	4%	5%	8%	6%
	Yes	94%	95%	92%	97%	96%	95%	92%	94%
Business size	**Up to 19 workers**	12%	9%	6%	3%	10%	9%	6%	7%
	20 to 49 workers	13%	10%	9%	9%	9%	8%	7%	9%
	50 to 99 workers	14%	11%	10%	12%	11%	12%	11%	12%
	100 to 249 workers	16%	13%	15%	13%	20%	17%	16%	15%
	250 to 499 workers	11%	12%	12%	15%	14%	12%	16%	13%
	500 workers or more	35%	45%	49%	48%	37%	43%	44%	44%
Observations		700	791	783	830	429	800	787	5120

Source: OECD (2022), Microdata from the OECD AI surveys of employers and workers. Available via: https://www.oecd.org/future-of-work/reports-anddata/data-infographics.htm.

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HOW TO TACKLE THE SKILLS GAP? A QUALITATIVE SURVEY

Introduction

Artificial intelligence (AI) is a transformative force permeating various aspects of people's lives. The widespread integration of AI is expected to lead to a significant discrepancy between the skills required by employers and those currently possessed by the workforce, potentially leading to an increase in unemployment (Chrisinger, 2019).

This chapter analyses the emerging skills gap related to the development and implementation of AI in Slovenian companies. It focuses on understanding how companies view the skills needed for AI, if they observe any critical skills gaps and if they can find the right talent for AI's current and future implementation. It also examines areas where additional skills may be needed and assesses how companies are prepared to address these gaps through training and other efforts. Additionally, it explores how the rise of AI impacts future employment trends. The goal is thus to provide an overview of the current state of AI-related skills in business and how it will affect future employment.

To get a more comprehensive view of the topic, the chapter starts with a literature review that deals with the skills gap and its solutions, including some of the best practices from abroad. An empirical analysis of the situation in Slovenian companies follows, based on the interviews conducted with human resource (HR) and tech professionals. The findings are combined, and some practical implications are given in the discussion.

1 Literature review

By 2027, more than 60 percent of workers will need to be retrained (World Economic Forum, 2023). The essential skills required due to the implementation of AI can be found in Table 1. However, only half of the population currently has access to sufficient training opportunities (World Economic Forum, 2023). Therefore, upskilling and reskilling remain key challenges for companies, employees, and job seekers. Many learners, even those without advanced degrees, are actively developing foundational AI skills such as data analysis and programming (Coursera, 2023). Individuals proficient in using AI can accomplish more tasks and demonstrate increased creativity and accelerated learning (McNeilly, 2023). However, the challenge is that AI does not require only hard skills that are specific to tasks and relatively easy to learn but also many soft skills that are more behavioural and develop over a longer period of time (Cimmati, 2016). When discussing industry-specific trends, several industries may experience significant negative disruption from AI, such as journalism, advertising agencies, design firms, the entertainment industry, IT, medicine, law, and accounting (McNeilly, 2023; World Economic Forum, 2023). About two-thirds of current jobs are exposed to some degree of AI automation. Moreover, up to one-fourth of current work could be substituted by generative AI (Hatzius et al., 2023). However, while certain job categories may decline due to technological advancements, AI also creates demand for skills in other areas, potentially leading to overall job growth (Chrisinger, 2019).

Nevertheless, the European landscape poses multiple challenges. Around 40 percent of EU workers perceive their skills to be underutilised, and nearly a third of college graduates feel overqualified (Lorraine et al., 2020). Additionally, the prevailing skills fall short by almost a fifth of what is needed for optimal job productivity. The digital era further complicates matters, as there is a growing demand for information and communication technology specialists (CEDEFOP, 2021).

Given the projected need for half of the workforce to have different educational qualifications, it is clear that there is a pressing need for comprehensive upgrading of the educational system (Abrahamsson & Larsson, 2021). Government funding, employer-provided training, cross-sector collaboration and diversity are crucial for AI education (OECD, 2023). Germany, Austria, Switzerland, the Philippines, New Zealand, India, Bangladesh, and China are already adopting dual training systems in partnership with industries to equip graduates with essential 21st-century skills and to enhance employability (Panth

& Maclean, 2020). Ireland, Germany, Finland, and Spain set an example by launching initiatives to improve AI skills through vocational training and lifelong learning (OECD, 2023).

Table 1. Overview of the skills needed due to AI implementation

Time			Skills less needed
Hard skills	Soft skills		
• Ability to use a computer or a smartphone; • Algorithmic auditing; • Cloud computing; • Comprehensive understanding of probability and statistics; • Data analysis; • Data visualisation; • Principles of machine learning; • Programming (Phyton, C/C++).	• Adaptability; • Communication; • Complex and creative problem-solving; • Coordination; • Creativity; • Critical thinking; • Emotional intelligence; • Empathy; • Ethics.	• Flexibility; • Judgement; • Management skills; • Multitasking; • Resilience; • Self-leadership; • Social perceptiveness; • Teamwork; • Unique worldview.	• Advising; Information ordering; • Memorisation; • Perceptual speed; • Planning; • Psychomotor skills.

Sources: OECD (2023); Chrisinger (2019); McNeilly (2023); Panth & Maclean (2020); Future Skills Centre (2023).

In collaboration with the government, organisations tackle the skills gap by identifying necessary skills, creating national skills maps, taxonomy, and skilling trackers, and incorporating standardised definitions and measurement methods. The best examples are Singapore's SkillsFuture program, which helps identify and master profession-specific skills; Germany's skills anticipation program, which predicts labour market trends; and LinkedIn's Skills Graph, which enhances global skill identification and mapping (Moldoveanu, 2022).

Companies are building extensive capacities at all levels (Brown et al., 2019) by introducing in-house academies with a common vision, language, protocol, customised content, and active apprenticeships, synchronising them with strategic goals and addressing hard skills, strategy, culture, organisation, talent, and change-management skills. Moreover, social and community-led hands-on projects, coaching, on-the-job training, and data relevance motivate employees to improve their skills. According to research from companies from the US, UK and Ireland, they prefer upskilling current staff due to cost-effectiveness. However, reluctance arises from fears of staff turnover and challenges like lack of motivation. Recruitment now emphasises courses and hackathons over degrees, followed by hiring contractors, partnering, outsourcing, and collaborating with academic institutions for future talent (SAS Institute, 2022).

Table 2. Sample characteristics

Company code	Interviewee code	Interviewee's position	Industry	Size	Location	Ownership
A	**HR-1**	Potential Management Director (HR, MKT)	Retail	Large	Ljubljana	Domestic
B	**HR-2**	Regional Head of HR	Manufacturing	Large	Ljubljana	Foreign
B	**HR-3**	HR	Manufacturing	Large	Ljubljana	Foreign
B	**HR-4**	Technology	Manufacturing	Large	Ljubljana	Foreign
C	**HR-5**	HR Manager	Manufacturing	Large	Outside Ljubljana	Domestic
C	**HR-6**	Digitalisation/Logistics	Manufacturing	Large	Outside Ljubljana	Domestic
D	**HR-7**	Director of HR	Manufacturing	Large	Ljubljana	Foreign
E	**HR-8**	HR Partner	IT	SME	Ljubljana	Domestic
E	**HR-9**	Head of Center of Excellence	IT	SME	Ljubljana	Domestic
F	**HR-10**	Head of Training & Development	Banking & Insurance	Large	Ljubljana	-
F	**HR-11**	Head of Future Technology	Banking & Insurance	Large	Ljubljana	-
G	**HR-12**	CEO	IT	SME	Ljubljana	Domestic
G	**HR-13**	Marketing & AI projects	IT	SME	Ljubljana	Domestic
H	**HR-14**	Head of HR	Manufacturing	Large	Outside Ljubljana	Foreign
H	**HR-15**	Head of Digitalisation	Manufacturing	Large	Outside Ljubljana	Foreign
I	**HR-16**	HR Professional in Training Center	Banking & Insurance	Large	Ljubljana	-
I	**HR-17**	Director of IT	Banking & Insurance	Large	Ljubljana	-
J	**HR-18**	AI researcher and developer	Research Institute	Large	Ljubljana	-
K	**HR-19**	BI Professional	Business Intelligence and Consulting	SME	Ljubljana	Domestic
L	**HR-20**	Data & Analytics Expert	Business Intelligence and Consulting	SME	Ljubljana	Domestic
L	**HR-21**	Head of Data Science	Business Intelligence and Consulting	SME	Ljubljana	Domestic

Source: Own work (2023).

2 Analysing AI-related skills gap in Slovenia

2.1 Methodology

A qualitative study was conducted to gather information on the skills gap related to AI in Slovenia. The goal was to target companies with some level of AI integration in their products or business processes and include companies from various industries. From September 4 to September 8, 2023, twelve semi-structured interviews were carried out, involving twenty-one representatives from twelve distinct companies comprising HR and tech departments and, in one instance, a CEO (HR-12). The interviews lasted from 45 to 90 minutes, most averaging around an hour. The sample characteristics are presented in Table 2.

The interviewees were first asked about the level of integration of AI in their company and the skills related to AI adoption. They were asked about the change in the need for skills AI brought, the importance of problems with hard and soft skills, and how both are checked. Further on, they addressed the capacity to cover their AI needs and discussed hiring AI personnel. They were also asked about the importance of the skills gap for their operations and development and how they tackle the gap and corresponding obstacles. Concerning the broader environment, they gave their opinion on the role of government and educational institutions in addressing the skills gap. Lastly, they were asked to name those who will benefit/lose the most due to AI adoption and to give some advice to managers, the government, and the young.

2.2 Results

2.2.1 Identified current skills gaps related to AI implementation

A large majority of companies have not yet faced dramatic changes in the needed skills due to AI implementation, which is, for many, still at an early stage with some use of generative AI. For most of them, the transition was relatively natural since they say, *"Learning is actually in our DNA. This is our culture"* (HR-8). The only two companies stating otherwise were Company D, with a lower rate of AI adoption due to security concerns, and Company F, which claimed more significant changes in restructuring and reskilling.

Most companies expressed the increased importance of certain hard and soft skills. Some stated that soft skills are *"much more important than the hard skills"* (HR-11) and that *"when you are approaching teamwork /.../ the importance of soft knowledge is rising. And also if you are trying to promote new technologies to your employees, you need to have soft skills"* (HR-6). Companies highlighted the importance of willingness to learn, agility, good communication, collaboration, active listening, analytical thinking, resilience, innovation and creativity, strategic and logical thinking, as well as problem-solving. *"One additional skill set which is also very important is critical thinking. And this part is usually quite challenging because here you should not blame, but you should critique"* (HR-11). Others did not necessarily pinpoint critical thinking, but most of them are aware that *"you cannot be reliant on artificial intelligence. It is not 100 percent bulletproof"* (HR-4), as it is necessary to evaluate the outputs of AI systems and ensure their accuracy and reliability. Furthermore, when using generative AI, the skill of prompt engineering is also important. "*You always have to ask the right question to get an explanation on how and on what the decision was made"* (HR-9). *"Right now, they are saying a lot of positions are closing, and they just need a position for prompting"* (HR-5).

However, despite the ever-emphasised importance of soft skills, hard skills are becoming a hot topic regarding AI implementation. *"I believe the combination of hard and soft skills is probably the best"* (HR-12). *"Hard skills, I would say, will always be needed. It only depends on how many people we still need with good knowledge of these hard skills and what hard skills we really need"* (HR-2). Hard skills that were mentioned were programming (Python, R, SQL), data management and data analysis, knowledge of specific AI tools and machine learning algorithms, but also more fundamental knowledge of mathematics, logic, and statistics. *"With AI technologies, it is hard to find individuals who can be multidisciplinary and have all the necessary skills"* (HR-19). The majority also mentioned the significance of knowing the business processes themselves. An important difference between the companies is to what extent they expect their employees to dive into the learning of programming. *"Basic knowledge should be a necessity for leaders. Not everyone should learn how to code, especially on lower levels where people do not need to make decisions"* (HR-18).

Most companies are looking for people to fill the positions that will also be in contact with AI. *"Currently, there are no suitable candidates with all the necessary skills in the market. Specific knowledge is required /.../ both in terms of understanding certain models and business processes and the data they generate"* (HR-15). This is why companies are not looking for people who have a full understanding of AI but rather those who are willing to learn and grow as AI develops further. Moreover, *"today the demand for this kind of [AI] solutions and consequently people who are able to build these kinds of solutions is increasing. /.../ Therefore, we are looking to reskill and upskill existing employees to move to a new direction of development"* (HR-11). It is also vital for companies to acknowledge the benefits of higher education for the sole purpose of successfully implementing AI models. *"When comparing education, however, there are big differences between having a PhD and other degrees. AI is a field where you need a research approach with a high level of abstraction, and PhD forces you to think on the level of theory"* (HR-18).

2.2.2 Addressing the skills gap

In addressing the skills gap, companies provide many different methods of educating employees. Employees are already learning by doing job shadowing, mentoring, coaching, attending online course workshops, sharing knowledge, and obtaining materials and certificates from external providers (e.g. Microsoft Learn, Google and LinkedIn). One company *"also prepared a 'campus' for the knowledge we have"* (HR-19).

According to eight companies, learning by doing and mentoring are the most effective methods of overcoming the skills gap in a company. Although, learning by doing was also mentioned to be one of the most time-consuming methods. *"The negative aspect of learning by doing is that the project takes longer to complete compared to having only senior developers on the team"* (HR-21). *"It is crucial to understand that even though profitability may decrease with this method, it is still an investment in the future"* (HR-20). Furthermore, companies also stated the importance of setting personal goals for each employee. *"We just need to be flexible, and we need to hear the people looking for the training. /.../ We need to customise our knowledge to their expectations"* (HR-8). *"Trying different methods is crucial so each person can find what they like the most, which approach"* (HR-19). On the contrary, some companies wish their employees were curious and explore new skills on their own. But *"people are not willing to invest their personal time to learn"* (HR-11). *"I need someone to be curious, to go the extra mile, to show that they want to learn something new"* (HR-1).

2.2.3 People as an obstacle in AI implementation

Companies are also facing some obstacles related to their employees when implementing AI. *"I would say that the mindset is the first one, the biggest* *obstacle. Because mindset is connected to how we are organised to work, how we decide, and how we prioritise"* (HR-11). Another important obstacle is an unwillingness to learn. *"They are looking for the quickest way to get results, and the majority of people are not investing their time in learning"* (HR-7).

Many interviewees observed obstacles on the organisational level – managerial as well as on the employee level. *"The management group is the most difficult because everything starts and ends there"* (HR-11). *"People who want to become managers in technology need to understand basic concepts to become leaders to empower the transition of the organisation"* (HR-18), *"but usually, they do not have enough time"* (HR-11). On the employee level, the biggest obstacle was regarding elderly employees. *"When we are talking 45 or older, the time they dedicate to learning goes down. /.../ but this is a generalisation"* (HR-10).

Fear may be an obstacle during the AI revolution when transitioning and replacing current job positions. *"Some people are afraid that they will be replaced by technology"* (HR-16). However, *"in the future, routine tasks can be replaced by AI, which gives individuals in such positions more room for creativity, ultimately leading to happier employees in terms of workload relief"* (HR-20). Therefore, *"a gradual introduction of new practices is essential, where people have the freedom to understand information, to ultimately gain trust in the change it brings"* (HR-15).

2.2.4 Recommendations

Many companies perceive AI as a buzzword and an opportunity for obtaining European funds rather than viewing AI as a comprehensive solution. *"Currently, there is a great panic regarding investments and the utilisation of available funds due to the fear of missing out"* (HR-20). For AI to succeed, it is crucial to have both advanced technology and trained employees. Companies should avoid the common reactive approach to developing employee skills and instead adopt a proactive approach.

Interviewees encouraged managers to recognise the value of core knowledge and expertise in specific fields as the foundation for effectively working with AI. Moreover, *"for the management, /.../ Do not wait, because this technology is developing so rapidly that the winner will take all"* (HR-11). *"We need to be open to change, open to new things, open to disruptive innovation. We need to be agile and move much more quickly"* (HR-13). Owners and managers *"should really start to think about their people, not like an asset, but really as their investment in the people"* (HR-7).

The government was addressed from both an educational point of view as well as their role in supporting businesses. Regarding education, the advice was *"not to skip some fundamentals"* (HR-3). *"A good time to start teaching such fundamentals would be in high school, especially grammar schools, in the form of connecting the fundamentals of mathematics and computer science"* (HR-18). However, *"AI knowledge and skills should be incorporated into school and college curricula since AI is becoming one of the general digital literacy aspects"* (HR-16). Five companies specifically stated that *"the government handles problems very poorly"* (HR-14), while the rest of them just implied that the government could do more.

Lastly, they encouraged the young entering the labour market to *"focus on acquiring both hard and soft skills and be aware that lifelong learning is crucial"* (HR-17). One of the proposed ways of obtaining knowledge is by *"taking advantage of everything available online since everything is becoming more and more accessible"* (HR-19). Therefore, *"learn, explore, and think how you can use these insights to work together more productively"* (HR-3). Moreover, in light of newer generations becoming more agile than ever before, one advice *"is to be patient, follow your passion, and do not make it too complicated"* (HR-18).

3 Discussion

Companies are at different levels of AI adoption, caused by both the peculiarities of the industry and corporate culture. Distrust and fear of data leakage hinder the introduction of AI in some companies. At the same time, the most successful implementations are observed in firms with an established tradition of knowledge sharing and continuous learning. In literature, there was a great emphasis on soft skills. The company's representatives agreed that critical thinking, lifelong learning, adaptability and other qualities are more important than ever in the current situation. However, hard skills have become an increasingly important aspect, and based on the conducted interviews, basic programming knowledge, data management, and algorithms are considered important, if not among all employees, then among managers. AI may take over many tasks nowadays performed by humans, but to capture its main advantage, people need to see it as complementary to their work. In this case, fundamental knowledge and skills such as mathematics, statistics, and logic become critical to understanding AI models.

When working with AI, companies struggle to find suitable candidates with comprehensive skills in the field, mirroring the World Economic Forum's (2023) forecast of 60 percent of the workforce needing retraining by 2027. While the companies are not necessarily looking for AI experts, they prioritise those willing to learn and grow with AI's evolution, implying a need for both specific technical knowledge and the ability to understand AI models and a deep understanding of associated business processes and the data they generate.

However, most interviewed companies are still active in addressing the skills gap using various methods, highlighting learning by doing and mentoring as the most effective ones. These were also among the preferred methods in the literature overview of the world's best practices. One company is even creating an in-house academy. Still, there are some obstacles, such as a lack of curiosity and eager mindset, age discrepancies and lack of time. Although some fear among employees can be detected, the interviewees believe AI can bring many more benefits than drawbacks in the form of room for creativity and workload relief. Nonetheless, it was emphasised that personalisation in methods used and gradual integration are needed to build trust within the workforce.

Table 3. Summary of key findings

		Key highlights
General findings		Importance of learning culture, gradual transition to using AI.
		Focus on employees who are willing to learn and grow with AI.
Soft skills needed		Willingness to learn, agility, good communication, collaboration, active listening, analytical thinking, resilience, innovation, creativity, strategic and logical thinking, problem solving, curiosity and critical thinking.
Hard skills needed	**Fundamental skills needed**	Mathematics, logic, statistics.
	Other hard skills	Programming, data management, AI tools, machine learning algorithms, understanding of processes, prompt engineering.
Educational methods		Learning by doing, mentoring, job shadowing, coaching, online courses, workshops, knowledge sharing, and external certifications.
		Personalisation of goals and educational processes, an array of methods.
Obstacles		Mindset, time, willingness to learn, age, fear.
Macro situation		Need for government's action, agility of the education system, collaboration of industries and the educational system.

Source: Own work (2023).

Lastly, the companies shared their opinion on the role of the state and universities in AI implementation and the necessary skills development, and their opinion was largely confirmed by the literature. The government's actions are, in many cases, perceived as insufficient. It should be more active in creating large-scale programs to tackle the skills gap. Concerning the education system, it should introduce more fundamental AI skills, adapt faster and work together with industries. The key findings of the empirical research can be found in Table 3.

Conclusion

Overall, there is not much evidence that the investigated Slovenian companies face significant struggles in connection to the AI implementation so far. However, it is important to note that the majority of the interviewed companies are still at an early stage of adoption. Most companies are seeking ways to improve their current level of skills and ways to adapt faster to the growing need for soft and hard skills. The ability of lifelong learning is becoming increasingly important amid the rapidly pacing trends. Additionally, the importance of gradual transition, change management, and learning culture needs to be highlighted. While the need for new hard and soft skills to handle AI should be recognised, building strong fundamental and learning skills is also necessary.

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UNVEILING THE PUBLIC SENTIMENT: A STUDY OF PERCEPTIONS TOWARD USING AI TECHNOLOGIES

Introduction

In recent years, rapid technological advancements have triggered significant changes, occasionally accompanied by discomfort due to their novelty and transformative potential (O'Shaughnessy et al., 2022). With all of the recent discussions regarding artificial intelligence (AI) and its potential harms and developments, the comprehension of public sentiment is vital because the public is a key stakeholder in shaping the future of this technology and should have a voice in policy discussions (Zhang, 2021).

Recent research reveals a spectrum of mixed feelings among individuals (Sidermann et al., 2020). Certain regions, including North America, Southern, Northern and Western Europe, are concerned about potential harm stemming from AI and robots. In contrast, Southeast and East Asia embrace these advancements as transformative and beneficial (Neudert et al., 2020). Most people in the European Union and Slovenia hold favourable views of AI technologies in their daily lives (European Commission, 2017).

This chapter summarises and discusses research findings on Slovenian public sentiment towards AI. The research focuses on three research questions: (1) what is the general sentiment people have towards AI (including generative AI), (2) how comfortable are people with using AI technologies in their daily lives, and finally (3) how do people see the future of AI.

Structured into three sections, this chapter begins with a literature review, discussing the broader landscape of AI sentiment, encompassing public perceptions, attitudes towards AI applications, and a future outlook. Then, empirical research findings demonstrate how individuals perceive AI technologies. Finally, the insights obtained from the research are summarised, providing a comprehensive overview of public sentiment concerning AI.

1 General sentiment of people towards artificial intelligence

1.1 Perception of AI among people

Recently, consumer perceptions towards AI have been changing substantially based on the ascent of AI systems. It was found that different parts of the world have different views about AI making decisions (Kaya et al., 2022). The research showed that some people are worried that the development of AI and robots might cause harm. This concern is mostly seen in North America, Latin America, Southern Europe, and Northern/Western Europe. On the other hand, some individuals view these advancements as beneficial, particularly in Southeast and East Asia (Neudert et al., 2020).

Nearly nine in ten survey respondents from America believe AI will be transformational, leading to a technological revolution, with the anticipation that AI-powered machines will handle routine tasks (Edelman, 2019). Moreover, Americans are more concerned than excited that AI systems also fail and make mistakes (Rainie et al., 2022). Looking at the public sentiment towards AI by British adults, the words describing their feelings were worried, unsure, scary, wary, useful, concerned, nervous, dangerous, curious, helpful, unhappy and many more (Farbrace et al., 2023).

More than one-third of Americans expressed more concern than excitement regarding the increasing use of AI in daily life, compared to only 18 percent, who are more excited than concerned. Around 45 percent are equally concerned and excited about the increased presence of AI in daily life. Among those who are more excited, 31 percent believe that AI has the potential to significantly improve various aspects of people's lives. Around eight percent of participants worry about AI becoming too powerful or being abused for nefarious purposes (Rainie et al., 2022). Furthermore, 35 percent of Americans stated they are curious, but many more say they are scared, excited and uninterested. Therefore, Americans have mixed feelings regarding these technological advancements (Feldman et al., 2023).

1.2 Generative AI

Generative artificial intelligence (GAI) describes algorithms (such as ChatGPT, Dall-e and Midjourney) that can be used to create new content, including audio, code, images, text, simulations, and videos (McKinsey and Company, 2023). Globally, half of the individuals included in the Capgemini research knew recent trends in generative AI and used the tools offered by it. Also, 73 percent of individuals trust the content created by generative AI, and around half of all respondents use the tools that include this technology. Regarding trust, small variations were found between men and women, but with higher household income, the level of trust in generative AI increased. Individuals see financial or medical advice from these tools as credible. Not only are these tools used for advice, but also half of the respondents use these tools for creative purposes, which may decrease the amount of unique human-generated content (Capgemini Research Institute, 2023).

Consequently, due to the high level of trust, individuals are not worried about fake news that may be created by generative AI. In fact, 49 percent of participants in the research remained unconcerned. Generative AI offers greater efficiency; for example, tools like ChatGPT, with its clear and personalised responses, create a situation where individuals may equate this clarity with accuracy. The fact that Microsoft and Alphabet support generative AI tools further increases trust levels. Because of the perceived accuracy, 70 percent of individuals are looking for product or service recommendations on generative AI tools like ChatGPT, which is replacing traditional methods like looking for information on search engines (Capgemini Research Institute, 2023). Moreover, consumers believe chatbots offer real and trustful information (Mehta et al., 2022).

1.3 The use of AI and robots

AI gives robots the ability to learn, adapt and make decisions, which provides them with functions similar to those of humans. Therefore, it is also interesting to explore individual perceptions of robots. Individuals in the European Union expressed different levels of acceptance of using robots. Firstly, around 25 percent of individuals said they would be comfortable with having a robot perform a medical operation on them. Also, the same percent of individuals stated they would be satisfied with having a robot to provide them with services and companionship. Furthermore, it was found that more than one-third of respondents would be satisfied by having a robot assist them at work. The same percentage of individuals was comfortable receiving goods delivered by a drone or a robot. Lastly, the study showed that respondents are less likely to be less comfortable with being in a driverless car (European Commission, 2017).

Respondents from the European Union, including Slovenia, showed that a majority of respondents have a positive outlook toward robots and AI. Approximately two-thirds of the population hold a favourable view of these technologies, largely due to their assistance in work-related tasks and daily tasks at home. Moreover, individuals in the European Union who have encountered information about AI within the past year tend to exhibit more favourable perceptions (European Commission, 2017). Moreover, 92 percent of participants from Finland, Russia and Singapore expressed discomfort with sharing their personal data with artificial intelligence (Milosheska, 2019).

Table 1. Perceptions about AI

Aspect of AI perception	Positive findings	Negative findings
Perception in different regions	• Concerns about AI: low in Southeast and East Asia. • European Union: positive view. • Slovenia: positive, appreciated assistance in daily tasks.	• Concerns about AI: high in North and Latin America. • UK: mixed feelings, concerns about global manipulation, surveillance and cyberattacks.
Trust in generative AI	• Trust content generated by AI. • Concerns about fake news. • Seeking recommendations for a product/service. • Credible for financial and medical advice.	• Decrease in unique human-generated content.
The use of AI and robots	• Comfortable with medical operations and services provided by robots. • European Union: comfortable with robots assisting at work and delivering goods. • Americans: evenly divided on who should regulate AI (government or businesses).	• Driverless cars trigger discomfort. • Finland, Russia and Singapore: discomfort with sharing personal data. • Privacy concerns.

Source: Own work based on secondary research (2023).

Americans are almost evenly divided on whether the government or businesses should regulate AI. Around 53 percent of Americans believe that AI should be regulated and controlled by the government. On the other hand, 44 percent of Americans believe that the companies producing this type of technology should be responsible for developing AI to minimise harm (Feldman et al., 2023). However, it was found that Europeans believe that AI systems need to be supervised. In Slovenia, 89 percent of respondents believe these technologies necessitate careful management (European Commission, 2017). However, concern for careful use of AI and robots should be at the forefront due to the increase in cyberattacks, global manipulation, and surveillance (Fietta et al., 2022). Table 1 summarises the main findings.

1.4 The future of AI

When it comes to the future perception of AI, views are mixed. Individuals are almost equally divided in their feelings of discomfort towards the future uses of AI. But, it is still believed that AI will allow progress and economic development in the future (Schepman & Rodway, 2020). Predictions suggest that by 2045, artificial intelligence will surpass human beings as the most capable life forms on the planet (Klokus, 2015).

In the European Union, most people believe the use of robots and AI will result in a decrease in job numbers, but only a minority think a robot or artificial intelligence could do their job. In Slovenia, 70 percent of respondents believe that AI will steal people's jobs, although only 43 percent of the same respondents think their job can be done by robots or AI. Moreover, most Slovenians believe that AI's rise will lead to more job losses than new opportunities (European Commission, 2017).

2 Methodology

An online survey was conducted in the Slovenian language to gain insight into various aspects of how the Slovenian public sees AI. The survey asked about feelings towards AI and robots (including generative AI), how comfortable the public is with the usage of AI in daily life, and expectations about AI in the future. The questionnaire was constructed by using adapted questions and scales from different scientific articles and reports (Rainie et al., 2022; Capgemini Research Institute, 2023; European Commission, 2017; Farbrace et al., 2023; Feldman et al., 2023; Feridun et al., 2023; Fietta et al., 2022; Kelly et al., n.d.; Mehta et al., 2022; Modhvadia et al., 2022; O'Shaughnessy et al., 2022; Schepman et al., 2020; Zhang, 2021).

Using convenience and snowball sampling, participants were recruited by email and social media. The questionnaire was accessible for participation from 4 September to 14 September 2023. Most of the statements were measured on the Likert scale from 1 to 5; only the sentiment towards artificial intelligence and sentiment about tasks performed by robots in the future were measured on the Likert scale from 1 to 10. A total of 447 responses were collected, with 371 surveys being fully completed. The respondents were aged between 18 and 88, with an average age of 32. Among the survey participants, 40 percent identified as male, while 59 percent identified as female. Additional details are available in Table 2. The majority of respondents had completed a first-level Bologna degree (38 percent) and earned between €1,600 and €2,200 per month (23 percent).

Table 2. Socio-demographic data of respondents

	Frequency	%		Frequency	%
Gender			**Age**		
Female	220	59	**Youth (15–24 years)**	148	40
Male	150	40	**Adults (25–64 years)**	212	57
I do not want to answer.	1	0	**Seniors (65 years and over)**	11	3
Education			**Net monthly income range**		
Primary school	6	2	**Up to €500**	44	12
Vocational school	8	2	**From €501 to €1000**	69	19
High school	63	17	**From €1001 to €1600**	60	16
University	27	7	**From €1601 to €2200**	86	23
Bologna First Level	140	38	**From €2201 to €3100**	39	11
Bologna Second Level	89	24	**Over €3100**	19	5
M.Sc. or PhD	38	10	**I do not want to answer.**	54	15

Source: Own survey (2023); N = 37.

3 Survey results and discussion

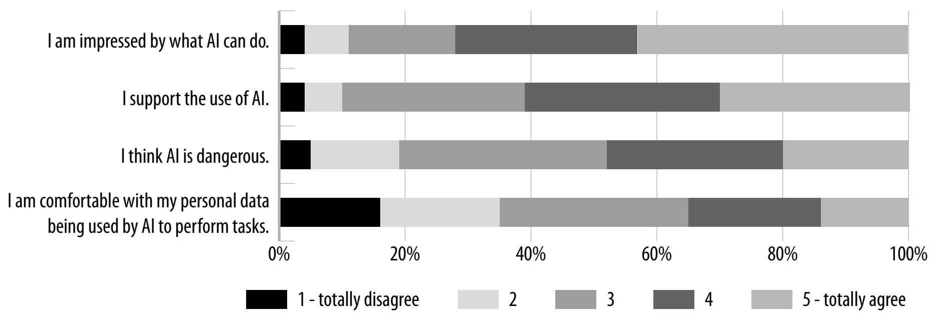
The respondents were asked to name the first word that crossed their minds upon hearing the term ‘artificial intelligence’ (Figure 1). Approximately 25 percent of respondents mentioned ‘robot’, 17 percent referenced ‘ChatGPT’, and 15 percent associated it with ‘computers’. About six percent mentioned ‘AI’ directly.

Figure 1. Word cloud of associations about AI

Source: Own survey (2023); N = 438.

Around 90 percent of respondents have heard, read or seen something about AI in the last six months. On average, respondents agree or strongly agree with the statements that they are impressed by what AI systems can do (mean = 4.0) and that the current development of AI causes changes in their lives faster than they can adapt (mean = 3.9). That may lead to experiencing fear towards AI. Furthermore, on average, individuals responded that they agree with using AI (mean = 3.8) and believe that artificial intelligence is dangerous (mean = 3.4). This observation is interesting since, as explained above, respondents are mostly impressed with what AI can do but also think it is dangerous, showing contradictory sentiments and perceptions. Negative perception may also result from people's inability to adapt to changes these technologies are causing. Regarding AI using respondents' personal data to perform different tasks, it was found that, on average, respondents are indifferent (mean = 3.0). It would be expected that respondents who consider AI dangerous would be unwilling to share their personal information with AI, which indicates respondents' trust in these technologies, which will be further discussed below (Figure 2).

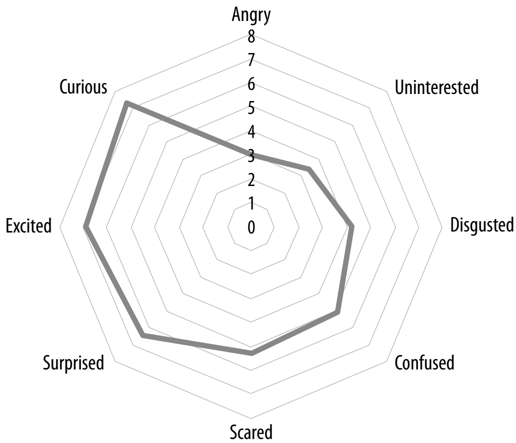
Figure 2. Respondents' sentiment towards AI



Source: Own survey; N = 406.

From the analysis of feelings (Figure 3), respondents are, on average, curious about AI (mean = 7.3), followed by excitement (mean = 6.9) and surprise (mean = 6.4). These findings align with individuals' positive feelings and show an excellent opportunity for future development and implementation of AI. However, on average, respondents are indifferent regarding being scared and confused. On average, people feel little or no disgust towards AI (mean = 4.2), which is an opportunity for the future. The fact that respondents see AI as dangerous but agree that it is trustworthy again shows the contradiction. Also, it is crucial to find the proper way to bring AI closer to people so that they perceive it as less dangerous. Looking at the disinterest and anger towards AI, respondents, on average, do not feel them.

Figure 3. Public sentiment towards AI



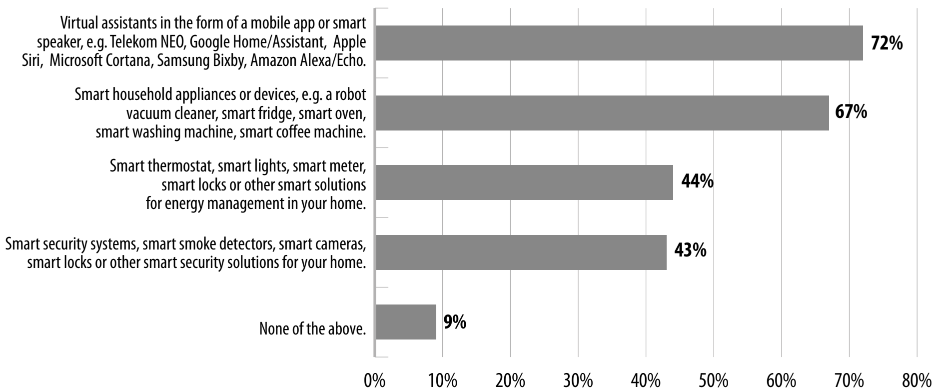
Source: Own survey (2023); N = 393.

Regarding perception towards generative AI, it was found that respondents are, on average, concerned about fake news that might be created by generative AI (mean = 4.0). Here, the role of governments and companies in charge of developing trustworthy AI becomes vital to prevent the spreading of fake news and develop systems to help detect it. Furthermore, individuals are, on average, worried that generative AI diminishes the value of human-generated content (mean = 3.8). On the other hand, respondents are, on average, indifferent regarding AI assisting them in financial planning and giving them recommendations. In terms of whether individuals would benefit from getting a medical diagnosis from generative AI, respondents, on average, do not have a comfortable attitude towards this (mean 2.8). The majority of respondents

(79 percent) have already used generative AI. This observation implies that, in reality, people may not have as much trust in generative AI or may only use it for basic decision-making or help. In contrast, for more important tasks, the level of trust decreases.

Furthermore, respondents, on average, generally agree with the statement that AI systems need to be supervised (mean = 4.5), that companies should be responsible for the development of accurate and unharmful AI systems (mean = 4.3) and that the government should be regulating and limiting the risks of AI (mean = 4.2). Cooperation between governments and companies seems to be needed to develop a trustworthy system. Furthermore, on average, respondents believe that AI helps make better decisions (mean = 3.7). Based on Figure 4, respondents mostly use virtual assistants, followed by smart household appliances, smart energy management solutions, and integrated smart security systems.

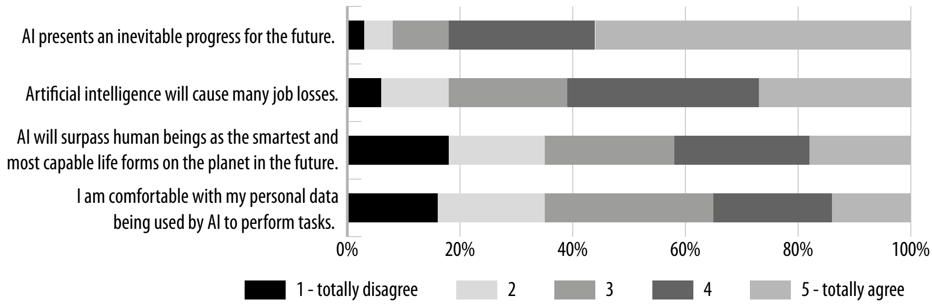
Figure 4. Respondents' usage of smart devices and systems for private purposes



Source: Own survey (2023); N = 372.

Regarding the future (Figure 5), the respondents, on average, agree that AI represents the inevitable progress of the future (mean = 4.3) and that AI will lead to job losses (mean = 3.6), which may be another reason why people see AI as dangerous. When asked about whether AI will surpass humans as the most intelligent and capable life form in the future, respondents are, on average, indifferent (mean = 3.1). That is another indicator that respondents are unsure where AI may lead humanity.

Figure 5. Respondents' agreement with the future of AI



Source: Own survey (2023); N = 389.

When asking respondents about their comfort levels regarding different situations that may happen in the future, it was found that they are the most comfortable with drone or robot deliveries (mean = 7.8). Then, they are in favour of robot assistance at work (mean = 7.1). Next, on average, individuals feel comfortable with robots helping them when they are older or have a disability (mean = 6.2). As seen from the research, respondents are indifferent to medical procedures being performed by a robot instead of a surgeon or the robot driving a driverless car in traffic. In complex and life-threatening tasks, most respondents prefer to have humans in charge. The main findings of this chapter and its implications are shown in Table 3.

Table 3. Key findings

Topic	Findings	Implications
Sentiment towards AI	• Mixed feelings towards AI. • Curiosity, excitement and surprise. • Trust in AI technology.	• Companies and government engagement.
Concerns about the usage of AI technologies	• Diverse attitudes towards AI. • Government intervention for AI regulation.	• Businesses should prioritise the safety and accuracy of AI systems. • Active government engagement in AI governance. • Education for threats and taking preventive steps to be safe. • Education of broader society. • Preventive steps.
Perception of the future of AI	• AI for future development. • May cause many job losses.	• Policymakers need to make regulations. • The educational system should adapt faster to changes (reclassifications, courses). • Businesses: reassuring that no layoffs will happen with AI.

Source: Own survey (2023).

Conclusion

The study encountered some limitations, notably in data collection, where resource constraints influenced the extent of the primary research. A significant limitation was the scope of the primary research, driven by time constraints, leading us to rely heavily on convenience and snowball sampling methods. Limitations of the study also include gender imbalance, with a higher representation of female respondents (57 percent) compared to males (43 percent). Additionally, the sample predominantly comprises individuals up to 32 years old, with nearly 70 percent falling within this age range. Furthermore, the respondents exhibited varying levels of education, with 33 percent finishing the first Bologna cycle, while seven percent have finished the second Bologna cycle or even the third one. Thus, the sample may include people who are more educated than the average population in Slovenia. Consequently, the findings may hardly be generalisable.

There are many mixed emotions surrounding AI, reflecting the intricate nature of this subject, given the uncertainties surrounding its development. While the majority acknowledges AI as the future with vast growth potential, the initial acceptance of this technology remains a critical challenge for both society and companies. Bridging the gap and bringing AI closer to people is a significant endeavour that lies ahead.

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TACKLING CYBERSECURITY CHALLENGES IN THE AGE OF AI

Introduction

In an increasingly interconnected digital landscape, the imperative for robust IT security measures cannot be overstated. Modern society relies on the continuous operation of information systems and networks. While rapid technological advancements benefit society, they also give rise to increasingly sophisticated cyber threats. These threats are used for criminal activities, terrorism, and political, economic, and military dominance. Large-scale cyberattacks can disrupt the economy and endanger lives, making cyber risks a top security concern crucial for national security (Ministry of Public Administration, 2018).

Industry standards provide a framework for organisations to implement best practices and guidelines for protecting their information assets, helping them identify and mitigate risks, reduce the likelihood of a cyberattack, and improve their ability to respond effectively. When implementing these industry standards for cybersecurity, it is crucial to consider the specific needs and requirements of the organisation (ISO, 2022).

This chapter will provide a comprehensive exploration of IT security strategies within various industries, delving into risk and impact analysis while considering the unique threat landscape each sector encounters. The research questions revolve around several key aspects of cybersecurity within organisations. The questions inquire about the methods companies employ to secure their digital infrastructure and how they convey their cybersecurity measures to the public. Additionally, the research seeks to understand companies' perspectives on the risks associated with potential data breaches and the extent of their financial investments in safeguarding their systems. Lastly, it aims to gauge the overall preparedness of companies at each stage of the cybersecurity framework.

The chapter begins with an outline of cybersecurity threats in Slovenia, encompassing a general overview and threats categorised by sector, which will be concluded with an overview of protective measures in the country. Following that, the research design will be discussed, with attention given to the role of cybersecurity in corporate strategy, the risks identified through interviews, and the security measures employed.

1 Cybersecurity in Slovenia

1.1 Cybersecurity threats in Slovenia

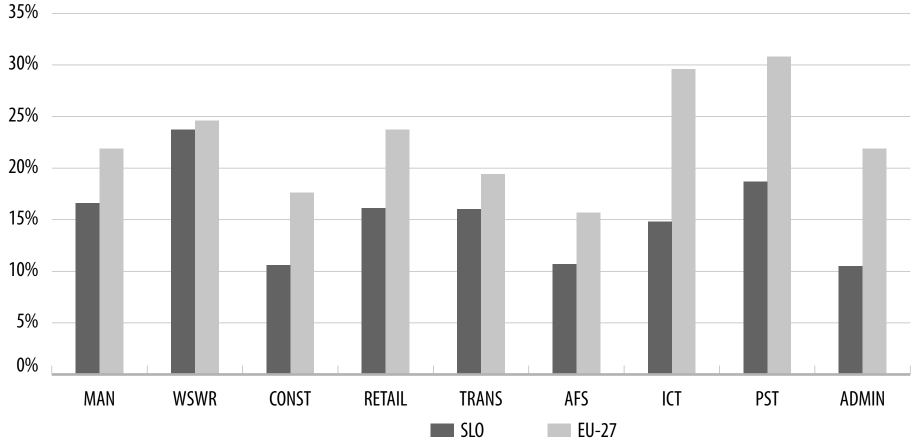
In Slovenia, the first step towards regulation was taken in 2016 with the adoption of the Cybersecurity Strategy. In 2017, the Government Office for the Protection of Classified Information (UVTP) was designated as the competent authority for national cybersecurity. SI-CERT, the national response centre for cybersecurity, has been monitoring threats since 1995. Fortunately, Slovenia has not yet faced any extensive cyberattacks, except for minor incidents in 2012, the WannaCry ransomware attack in 2017, which caused some financial damage (Ministrstvo za javno upravo, 2018), and the 2022 cybersecurity breach in the Slovenian Civil Protection Administration where the breach allowed cyber attackers to exploit vulnerabilities in the system handling emergency calls (Cirman & Modic, 2022).

In 2022, SI-CERT dealt with a total of 4,123 cybersecurity incidents. Roughly estimating the breakdown, it appears that 30 percent of these incidents were technical attacks, another 30 percent involved social engineering, and the remaining 40 percent comprised phishing attacks. The last year's number of incidents marks a noticeable increase compared to the previous years, as in 2021, there were 3,177 incidents, and in 2020, there were 2,775 incidents. Notable financial impacts included (SI-CERT, 2023):

- Business Email Compromise (BEC) had the potential for €3,000,000 in damages.
- The highest individual damage recorded was €400,000 due to extortion.
- Phishing attacks averaged around €3,400 (ibid).

The most affected sectors in EU-27 were the ICT sector (29.6 percent), professional, scientific, and technical activities (30.8 percent), and water supply; sewerage, waste management and remediation activities (24.6 percent). The least affected sectors were construction (17.6 percent) and wholesale and retail trade, repair of motor vehicles and motorcycles (23.7 percent). These differences can be explained by the fact that the ICT sector relies heavily on digital technologies, often has a large amount of sensitive data, and may have less mature security practices than other sectors (Eurostat, 2023a). On the other hand, in Slovenia the most affected sectors were water supply; sewerage, waste management and remediation activities (23.7 percent) and professional, scientific and technical activities (18.7 percent).

Figure 1. Enterprises that experienced any ICT security-related incidents leading to unavailability of ICT services, destruction or corruption of data, or disclosure of confidential data (for any reason) in 2022 for Slovenia and EU-27, in percent



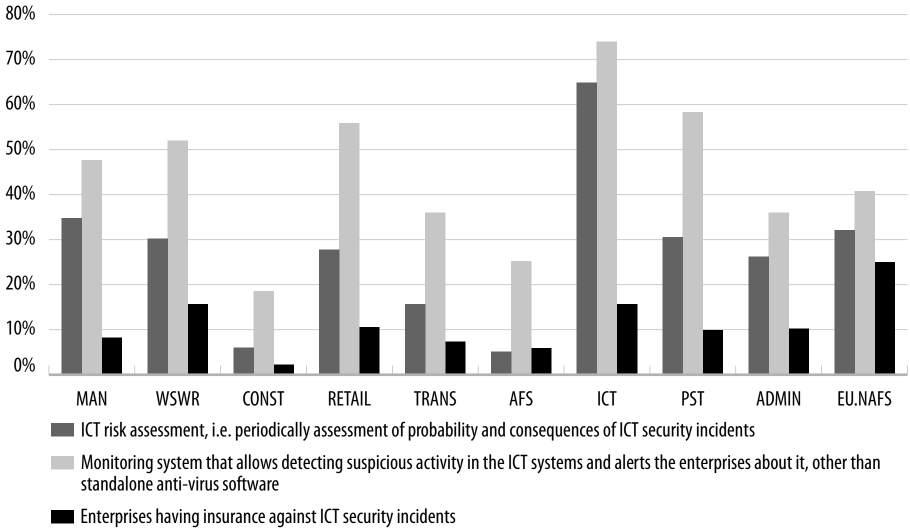
Note: MAN - Manufacturing; WSWR - Water supply, sewerage, waste management and remediation activities; CONST - Construction; RETAIL - Wholesale and retail trade; repair of motor vehicles and motorcycles; TRANS - Transportation and storage; AFS - Accommodation and food service activities; ICT - Information and communication; PST - Professional, scientific and technical activities; ADMIN - Administrative and support service activities.

Source: Eurostat (2023a).

In Slovenia, notable disparities among sectors are evident in ICT risk assessments (i.e. periodic assessment of probability and consequences of ICT security incidents) for 2022, as illustrated in Figure 2. The ICT sector leads with the highest adoption rate at 64.9 percent, while the construction sector trails behind with the lowest rate at 6 percent. Similarly, the adoption of monitoring systems that detect suspicious activity in the ICT systems and alert the enterprises about it varies significantly in Slovenia, with the ICT sector at the forefront, boasting a rate of 74.1 percent. In comparison, the construction sector lags at 18.6 percent. Furthermore, insurance coverage for ICT security incidents is relatively modest in Slovenia, with the ICT sector leading at 15.7

percent but the construction sector significantly behind at 2.3 percent. However, compared to EU sector averages, these variations become even more apparent, underscoring the pressing need for increased adoption of risk assessments, monitoring systems, and insurance coverage to align with European standards in ICT security (Eurostat, 2023b).

Figure 2. ICT risk assessment, a monitoring system other than standalone anti-virus software, and enterprises having insurance against ICT security incidents in 2022, in percent



Note: MAN - Manufacturing; WSWR - Water supply; sewerage, waste management and remediation activities; CONST - Construction; RETAIL - Wholesale and retail trade; repair of motor vehicles and motorcycles; TRANS - Transportation and storage; AFS - Accommodation and food service activities; ICT - Information and communication; PST - Professional, scientific and technical activities; ADMIN - Administrative and support service activities; EU.NAFS - All activities without the financial sector in the EU.

Source: Eurostat (2023b).

2 Research design

A qualitative study was conducted to gather relevant information and comprehensively explore IT security strategies within various industries in Slovenia. From 30 August to 20 September 2023, 11 semi-structured interviews were carried out either at the locations of the companies or via MS Teams. Most interviewees held the positions of IT Director or Chief Information Security Officer (CISO). Some were also other members of IT security teams and key decision-makers within the companies (Table 1). The interviews lasted between 30 and 120 minutes.

Table 1. Key information on interviewed companies and participants

Company Code	Industry	Gender	Interviewee's position	Interviewee code
CYBER-1	Automotive	Male	CEO	1
		Male	CIO	2
CYBER-2	ICT	Male	IT Manager	1
CYBER-3	Manufacturing	Male	Supply Chain Director	1
		Male	CISO	2
CYBER-4	Finance	Male	CISO	1
CYBER-5	Manufacturing	Male	CISO (IT Director)	1
CYBER-6	Tourism	Male	CISO (IT Director)	1
		Male	IT	2
CYBER-7	Pharmaceutical	Male	CISO	1
CYBER-8	IT	Female	CISO	1
		Male	IT Manager	2
CYBER-9	Manufacturing	Male	IT Director	1
CYBER-10	Pharmaceutical	Male	OT Security Lead	1
CYBER-11	Logistics	Male	CISO	1
		Male	IT	2

Source: Own work (2023).

3 Research results

3.1 Cybersecurity in the corporate strategy

Organisations are highly aware of the risks associated with cybersecurity. They prioritise three key components in their cybersecurity strategies: **confidentiality, integrity**, and **availability**. This viewpoint is supported by the statement emphasising the interconnectedness of these concepts, stating, *"All three concepts of cybersecurity are important because IT security is a chain of many measures that are* ***interconnected****. In fact, it is the weakest link that is the most dangerous in reality"* (CYBER-1).

However, according to this research, some companies seem to prioritise **availability**. *"In our company, information security is of great importance, particularly due to availability, as there is no break except for maintenance, 24/7. Production cannot be stopped"* (CYBER-5). This statement highlights the significance placed on availability in manufacturing due to the continuous and uninterrupted nature of their operations.

In some cases, companies may not prioritise availability at all. For instance, in the financial sector, **confidentiality** and **integrity** take precedence. "*We prioritise confidentiality and integrity as our main focus, while availability is not as significant"* (CYBER-4). This perspective aligns with the industry's need to maintain the confidentiality of sensitive financial information and ensure the integrity of transactions and data.

This divergence in priorities reflects the diversity of cybersecurity approaches within organisations. Some entities may prioritise the other two components, confidentiality and integrity, to such an extent that availability is relegated to a secondary position, or in some instances, it may not be considered a significant concern at all.

3.2 Cybersecurity risks

Five significant cybersecurity risks relevant across various sectors in Slovenia were studied. These risks include **environmental safety**, **human safety**, **production goals**, **product quality**, and safeguarding **sensitive information**.

Research revealed that the degree of cybersecurity threat organisations face often correlates with their level of digitalisation. Companies with a higher degree of digitisation tend to face more pronounced cybersecurity challenges due to increased digital exposure.

Sensitive information emerges as the most significant cybersecurity concern. In contrast, both production and product quality exhibit relatively high fluctuations in risk awareness across industries. It is important to note that human and environmental safety, while crucial, do not pose substantial cybersecurity threats because other effective safety measures are present.

In the context of **environmental safety**, it is noteworthy that most organisations, especially those in sectors other than hazardous industries, typically face minimal cybersecurity threats. This relative security is largely attributed to the incorporation of robust physical security measures within their operational framework. "*In terms of environmental safety, our primary concern is the possibility of spills involving dangerous chemicals. Nevertheless, we have robust physical safeguards in place to prevent such incidents"* (CYBER-7).

A similar pattern emerges in the context of **human safety**. *"Our production environment operates with limited digitalisation, using somewhat dated* *technology"* (CYBER-1). *"For production, we have an isolated setup, and the technology is somewhat outdated"* (CYBER-3). Furthermore, *"We do not have any interconnected systems. We have a plan to keep these devices in a separate network, like robots, which is physically isolated to prevent contact with humans"* (CYBER-2). Companies with extensive digital operations may face more intricate challenges, but they often complement their digital safeguards with robust physical protection measures.

Moreover, it is crucial to emphasise that safeguarding **sensitive information** remains a top cybersecurity priority across all sectors, regardless of their specific focus. *"Sensitive information poses a significant risk. We must ensure no data leaks occur, as they can lead to a loss of integrity and reputation"* (CYBER-5). In addition, *"If there were any disclosure of this data, it would have a negative impact on the company's reputation, as well as our business opportunities"* (CYBER-6). Furthermore, protecting sensitive information was highlighted by the manufacturing firm, *"It is important to prevent leaks of developmental data"* (CYBER-3).

When examining **production goals** and **product quality**, the research has unveiled notable disparities in the types of threats encountered across various sectors. In particular, manufacturing companies emerged as the most concerned in this regard. *"If a cyberattack occurs, something that should not be released to the market can potentially get out. This is undoubtedly critical"* (CYBER-7). But even then, they have physical control in place. *"The quality of products is ensured through manual inspections"* (CYBER-2).

3.3 Cybersecurity measures

This research has analysed the implementation and integration of core cybersecurity principles based on the National Institute of Standards and Technology (NIST) Cybersecurity Framework (CSF): **Identify, Protect, Detect, Respond,** and **Recover** (Federal Trade Commission, 2023).

3.3.1 Identify

Concerning the identification of cybersecurity risks, organisations often rely on standard risk assessment methodologies to **identify** these risks. Company 4 highlighted that they maintain a dedicated risk department that regularly convenes risk committee meetings. During these meetings, they review and define various risks, applying a classification process. However, the evaluation process often involves assigning grades or ratings rather than providing precise numerical indicators. *"We have the first risk department that regularly convenes at the risk committee. During this, we review and define all risks and classify them in some way. We also determine the number of annual assessments. These assessments are based on various questionnaires of different methodologies. We conduct annual interviews with specific employees to identify potential risks. We also extensively utilise an external threat intelligence team"* (CYBER-4).

These methodologies, though comprehensive, are typically designed for a broad spectrum of risk factors and may not provide a direct evaluation of the precise vulnerability levels to cyberattacks, often lacking specific numerical indicators. *"Management allows us to specify this based on risk assessments. We must periodically sit down with the leadership team and evaluate"* (CYBER-6).

3.3.2 Protect & Detect

According to this research, almost all companies protect themselves with the help of **employee training** and through data security and protection software. Most companies also have implemented EDR tools and appointed a CISO, which should be an independent role of the IT manager. *"Separation of roles between the CISO and the IT monitoring team is crucial to avoid conflicts of interest and ensure information security, despite the potential costs. Security must be a priority. It makes no sense to set the rules of the game and at the same time enforce and monitor them"* (CYBER-4). A small number of companies have **board-level** oversight and **insurance** protection. Among the interviewed companies, one company has sufficient insurance protection; others have problems with either finding appropriate insurance or are still in the stages of negotiating a good deal. *"We have been talking about it since 2018, 2019"* (CYBER-7).

On the other hand, **remote workforce** and **security skills shortages** are also present in almost all companies, which, contrary to **employee training** and data security and protection software, raise the costs of security breaches. But companies are well protected, especially in the scope of the remote workforce. According to the interviews, *"Access is regulated through policies where each employee has an individual user account. Access to information is allocated by job, which means that each job only has access to certain information"* (CYBER-7). *"Therefore, we have established an organisational regulation that clearly defines user rights. This way, the student, for instance, will not have access to sensitive information"* (CYBER-6).

The interviews showed that a large majority of companies have migrated to the cloud, but to protect themselves, they also keep a certain amount of hard copies. Some companies are also prone to supply chain breaches and can have their Internet of Things (IoT) and Operation Technology (OT) impacted by security breaches. Additionally, valuable insights were gathered from the interviewed companies on supply chain breaches related to third parties and whether the breach could be performed through them. They pointed out that *"the breach would be minuscule in such cases due to the services the third party performs for us"* (CYBER-6). Another way that companies can protect themselves is with the use of non-disclosure agreements (NDA). But only one of the companies specifically mentioned them. *"I might start with trade secrets because that is where we often begin in business. We always sign an NDA before even starting to work with someone, either during negotiations or in the preparation of an offer"* (CYBER-8).

3.3.3 Respond & Recover

In the context of cybersecurity practices in Slovenian companies, it is important to note that not all organisations have well-defined procedures for the **Respond** and **Recover** functions. For small threats, many organisations have implemented software solutions that can automatically neutralise or mitigate these threats without manual intervention. *"In the case of more substantial threats or security incidents, the standard procedure involves notifying all relevant parties, including partners and customers. This notification process is typically initiated by phone as the primary means of immediate contact, followed by emails and official correspondence"* (CYBER-7).

Notably, a formalised Business Continuity Plan is frequently absent. Therefore, the responsibility for recovery efforts is placed squarely on the Chief Information Security Officer or top IT personnel, potentially leading to challenges in managing and recovering from security incidents. A good recovery plan can help companies expedite the process of recovery following a cyberattack. *"We have an entire disaster recovery plan in place, which we call the 333 Recovery Plan. This plan consists of three hours for system recovery, three hours for data recovery, and three hours to get the company back on track. The entire disaster recovery plan is documented"* (CYBER-9).

Table 2 provides a summary of key findings for the implementation and integration of core cybersecurity principles in Slovenia.

Table 2. Key findings

Cybersecurity aspect	Key findings
Characteristics of cybersecurity in Slovenia	• An economic hurdle for SMEs; • Escalation of cyber threats; • Rising awareness; • Lack of awareness among unaffected companies; • Shift toward insurance; • ISO standardisation significance; • Certification driven by market demands.
Three key concepts: confidentiality, availability and integrity	• All concepts are highly interconnected, with some industry-specific nuances. • Cross-industry relevance; • Confidentiality: particularly important in manufacturing; • Availability: significantly important for manufacturing; • Integrity: plays a pivotal role in banking.
Perceiving risk associated with potential breaches	• Trade secrets present the overall highest risk. • Quality of product and production goals: especially important for manufacturing. • In case of a breach, human and environmental safety are protected by physical safety measures.
Companies prepared for every step of the cybersecurity framework	• Identify: - Companies are not fully aware of the exact financial damage. - Following safety standards. • Protect: - High usage of protective software. - Employee training. - Data encryption. • Detect & Respond: - High usage. - Extended detection and response. - Lean on MS Defender. - Low MTTI. • Recover: - Limited focus on recovery plans creation and testing.

Source: Own work (2023).

Conclusion

As artificial intelligence continues to progress within the business landscape, so do the challenges to cybersecurity. It is crucial to recognise that among these challenges, one of the most pronounced threats remains the risk of **human exploits**, as emphasised by two companies' insights: *"The biggest risk here is* *people"* (CYBER-9) and *"We are aware that employees are our biggest risk"* (CYBER-11).

In this rapidly evolving landscape, AI is not only advancing in the realm of business but also in the domain of **social engineering**. With the help of AI, attackers can now generate millions of attacks without specifically targeting individuals. *"On a quarterly basis, we detect approximately one million phishing emails globally"* (CYBER-10). *"On the internet, we are all only an IP Address. Attackers do not target specific firms"* (CYBER-11).

Companies must provide **proactive cybersecurity** measures to ensure ongoing cybersecurity effectiveness. They must **consistently** enhance their defences and stay ahead of evolving threats through continuous employee training, regular data security software upgrades, and the development of comprehensive business continuity plans. *"The biggest mistake we can make is to rely solely on technology"* (CYBER-10).

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IN CONCLUSION: BEYOND BITS AND ALGORITHMS TOWARDS AN INTELLIGENT ECONOMY

Introduction

Artificial intelligence (AI) began developing in the 1950s with a paper by Turing (1950), who asked whether machines can think. The path towards the level of the development of artificial intelligence today encompasses three major stages. The period from the 1950s to the 1970s contributed to the foundations of the algorithmic approach. From the 1970s to the 1990s, 'expert systems' aiming to encode human expertise as computer programs were developed. Then, the period from the 1990s to the 2020s contributed to the development of machine learning and deep learning (Redek et al., 2023b). The development of AI has been continuously dependent on the development of other related technologies, primarily computing capacity and the availability of large amounts of data. It will also increasingly depend on it in the future (Strier et al., 2022). The generative AI 'revolution' pointed to the ability of machines to think already today. However, AI technology still falls under 'weak' or 'narrow' AI, which simulates human behaviour within a specified set of parameters and context. In the future, two further breakthroughs are expected. 'Strong' AI or general artificial intelligence will signify machines that can simulate human thought processes and execute intellectual tasks. Additionally, when and if developed, 'super' AI is expected to surpass human capabilities (OECD, 2022).

The generative artificial intelligence (in continuing AI), which caused a significant shift in the awareness of the general population about the potential of technology, also led to a resurgence of optimism about the future productivity growth in developed countries and the ability of the countries to move towards *"sustainable, inclusive growth, and solve complex global challenges"* (McKinsey, 2023a, p. 4).

Artificial intelligence is expected also to boost GDP significantly. By 2030, European countries could benefit around 10 percent; GDP in the US is expected to be around 14 percent higher than today only due to AI, while the boost in China could surpass even 25 percent (Statista, 2023). The impact will result from several uses in different sectors and from the growth in both supply-side productivity and innovation as well as from the demand side, from consumption impacts, which will become gradually more important with increasing adoption and customer responses to new technologies (PWC, 2017). In the long term, the revival of economic conditions will hinge on how AI adoption influences income distribution. If advances in AI technology do not lead to increased wages, the diminishing share of labour income in the GDP will lead to reduced overall demand. This reduction, in turn, would hamper both the current and potential growth of the economy and hinder the creation of new jobs, causing further delays in boosting productivity and GDP growth (Gries & Naudé, 2021).

The lack of timely and relevant data prohibits a comprehensive evaluation of the impacts of AI. It also lowers the ability to monitor the progress of AI adoption. Official statistical data on AI use is available and follows a standardised, international approach to allow comparative analysis (Eurostat, 2022, 2023). However, due to the speed of the change, despite providing a comparative angle regarding the use in companies, the methodology fails to incorporate the most recent developments, such as the ChatGPT boom. Therefore, alternative indicators are being developed, such as the ones by the AI observatory (OECD & Jožef Stefan Institute, 2023), which relies on an innovative set of data that are more easily available (Marinšek et al., 2023; Požun et al., 2023). However, they do not offer a deeper insight, for example, at the level of companies or individuals, primarily not regarding the causalities, motives, or expected results. Thus, this book used a comprehensive multi-methodological approach, relying on desk research, survey data, official statistical data, alternative indicators as well as primary data collection in the form of survey data collection and in-depth interviews.

The book opened several topics, from the challenges of definitions, measurement, and corporate and individual perspectives, including the challenges individuals will face in the labour markets.

1 The corporate perspective – a comparative approach

Artificial intelligence will significantly disrupt standard business models and challenge business leaders and companies from multiple angles. AI is causing changes in many business processes, from production, management, IT, marketing and sales, R&D and innovative processes, human resource management, logistics and others, causing significant disruptions to existing business models.

In Europe, according to the most recent 2021 data, AI tools are used on the intensity in around eight percent of companies, with intensity significantly differentiating across sectors, with ICT sectors, also electricity and professional services using AI more intensely than the average (Eurostat, 2023). The intensity of AI use also increases with company size. Slovenian companies use AI tools more intensely. Around 11 percent of companies reported using AI in 2021 and 2023. Primarily, AI tools are used in the ICT sector, professional services, automotive, electrical equipment manufacturing and manufacturing of computers, as well as logistics. Companies use AI tools for several purposes, but most often in security, production, marketing and sales, and R&D and innovation (Redek et al., 2023b).

To more deeply understand the nature of AI adoption, the motives, the expected and actual results, and the challenges, four case studies were prepared, exploring AI adoption in wholesale, marketing, automotive sector and telecommunications (Table 1). In addition, due to the vibrant AI start-up scene, an analysis of AI supply was performed.

The comparison across different industries shows that the primary motives for using AI-based tools and other digital solutions are similar; companies are primarily driven by the desire to optimise processes, reduce cost, and improve quality, user experience and competitiveness, although these goals might differ in terms of means of achievement across different industries. Companies use various tools, from those available in the market and the cloud to those they develop themselves and in cooperation with outside partners.

Obstacles could be grouped into human/knowledge-related, technical and financial. Knowledge-related obstacles, lack of AI-related skills, and readiness to adopt across groups within the companies were mentioned, which can be solved in various ways, including cooperation with external partners like academia or start-ups. AI and other digital tools may require (depending on the type) a significant financial investment, particularly if it involves not just using AI as a complementary tool, where merging with existing solutions is a challenge, but especially where a substantial digital transformation in the company is planned. In addition, both the lack of existing regulation as well as compliance with regulation remain a challenge.

Table 1. A summary of the motives, challenges, and results of AI use in the studied companies

Business process	Selected highlights
General motives and expectations	Automation, optimisation of work processes, increased productivity, cost reduction, improved quality, robustness, transparency, improved user experience, removing routine tasks, business model transformation, and enhancement of comparative advantages.
Obstacles	Lack of skills within the company, readiness to adopt AI solutions varies across groups, cooperation with external experts (e.g., academia and start-ups), substantial investments, merging new solutions with existing IT solutions, compliance with regulation, and lack of regulation.
Types of (AI) tools used	AI-driven data analysis (e.g., Machine learning), LLM (e.g., ChatGPT), semantic analysis, big data, analytics optimisation and prediction, dynamic targeting, 3D-scanning, WMP, IMS, ERP, cloud analytics, robotic process automation, robot operating system, AI-powered voice recognition, and developing and marketing own solutions.
Management	The central role of management and its strategic orientation, attitudes of management towards technology, ensuring effective communication and the seamless flow of knowledge, the need to communicate the process of AI introduction and digitalisation, and the importance of risk management.
HRM	AI is weakly used in HRM, focusing on digitalisation and streamlining processes. Essential aspects of transformation: information sharing, peer support, knowledge and skills sharing, AI-driven education, and retraining and upskilling.
R&D	AI-driven innovation, cooperation with start-ups, and sustainability innovation.
Procurement Marketing, Sales	Potential in the integration of sales, purchases, personalised targeting, sales optimisation, personalisation, optimisation of stock, and warehouse costs. Challenges exist when dealing with uncertain events.
IT	A central role in technology adoption, new systems' integration, future planning, and internal communication.
Production	Utilisation of modern robots, with sensing and adaptation, efficiency, robustness, 24/7 operation if needed, flexibility of production lines, and reduction of physical strain.
Security	Security enhancements, fraud detection, robust data protection measures, and regulatory compliance.

Sources: Cirman et al. (2023), Koman et al. (2023b), Redek et al. (2023a) and Žabkar et al. (2023).

Companies use digital and AI-based solutions in different business processes. At the managerial level, primarily the strategic orientation towards the use of new solutions, effective communication of the need for transformation, support to the process, and efficient communication of plans and processes in terms of technological changes are important, as well as supporting obtaining necessary skills and knowledge. This aspect is closely related to HRM, where, in general, AI was not widely used in the studied cases. Digital tools were used primarily to streamline and digitise processes. The cases also highlighted the need for reskilling and upskilling as well as training and knowledge sharing, which can also be AI-based. Regarding the worker perspective, it was also stressed that using AI and other digital tools reduces the number of routine tasks and physical strain on the workers in production. The communication of the changes and training is supported by the IT departments, which also have an essential role in planning, development, integration and support.

Marketing, sales and procurement are business functions where AI has a lot of potential for optimisation of purchases, stocks, costs, personalised solutions for customers both in terms of marketing and sales, individualised targeting, as well as creative work in marketing. Creative work can be supported by AI also in R&D and innovation. In production, efficiency, quality and flexibility are increased using digital (also AI-based) solutions while reducing physical strain on the workers. It was also mentioned that digital solutions allow more time flexibility and operate 24/7.

In the future, AI-based solutions will become increasingly important. Consequently, security issues, data protection, and compliance will become critical to, on the one hand, protect the domain knowledge of the companies and, on the other hand, ensure that the processes are in line with the regulatory standards.

Slovenia also has a vibrant AI start-up scene (Koman et al., 2023a). AI is recognised as a problem-solving tool capable of tackling previously insurmountable challenges on a large scale. This growth in AI is leading to the specialisation of small start-ups, with companies focusing on specific verticals or niches in the market. Such cases, needing specific, flexible solutions, often favour smaller suppliers capable of offering tailor-made solutions. The market potential for AI suppliers is increased by a low adoption rate of just around 12 percent of companies with more than ten employees using AI technologies. In addition, there is also the option of venturing into international markets (Koman et al., 2023a).

Personalisation of AI solutions to meet specific client and industry needs is a crucial competitive advantage of these smaller suppliers (Koman et al., 2023a). Adoption and market size for smaller companies also depend on other factors. The primary cause of low AI implementation is often on the client side, encompassing affordability and understanding the value of AI solutions (Koman et al., 2023a). Pricing models are commonly offered, including subscriptions, per-product, per-project, or combinations thereof (Koman et al., 2023a). Lack of trust due to limited client knowledge also represents a demand constraint. For both suppliers and users of AI tools, recruitment of highly skilled personnel is challenging due to talent shortages in times of high employment. Significant capital investment is required for AI development, and custom solutions can be particularly expensive for clients (Koman et al., 2023a). For SMEs, the lack of digital data is a common obstacle to AI implementation, further limiting the demand (Koman et al., 2023a).

Smaller AI suppliers also face financial challenges. Companies typically apply for grants in their early stages, and some prefer venture funding to accommodate the fast pace of start-up innovation. Incentives for companies extend beyond monetary support, including education, mentorship, and support mechanisms for smaller firms. Funding should be directed towards economically viable projects without overly burdening companies with bureaucracy (Koman et al., 2023a).

2 AI and the future of labour

Artificial intelligence will also transform the nature of work, whether in the form of assisted intelligence, where AI assists humans in their tasks; augmented intelligence, where AI augments human decision-making; or even in the form of systems where the human involvement is no longer needed, such as automation and autonomous intelligence (PWC, 2017). The new tools offer opportunities; however, they also present significant challenges.

The survey data analysis of the use, perceptions and expectations of AI in the work processes in Slovenia (Domadenik et al., 2023a) revealed that AI is more widely used by men, especially in high-skilled jobs in the private sector. AI users report that AI contributes to more efficient work, saves time and improves product quality, especially in manufacturing. AI also improves employee performance and job satisfaction. However, there are some concerns about its impact on fairness in public and low-skilled jobs. Highly skilled workers in Slovenia are optimistic about the future of AI, while low-skilled workers are more worried about their wages. Interestingly, Slovenian workers are generally less concerned about job loss in two or ten years due to AI technologies than workers in other countries (Domadenik et al., 2023a).

The results for Slovenia were also compared with others for some OECD countries (Domadenik et al., 2023b). Generally, GDP per capita and digital readiness play a critical role in AI adoption, along with industry specifics and individuals' education. Interestingly, countries with high rates of AI adoption are more optimistic about its impact on working conditions. The situation in Slovenia is comparable to other investigated OECD countries regarding the impact of AI adoption on working conditions, which is found to be positive. The impact of AI is perceived as potentially improving workplace health, safety, and mental well-being. However, Slovenian respondents are cautious about the effects of AI on future wages and rather pessimistic regarding the possible impact on jobs. At the company level, AI adoption concerns can be managed using efficient communication and prudent management, which will speed up adoption, support use and lead to higher productivity and prosperity (Domadenik et al., 2023b).

Human resources and skills are often mentioned as one of the key obstacles in technology adoption. Investing in adaptive education and upskilling programs, strengthening labour market institutions, and ensuring responsible corporate engagement are vital in this transformation (Zupan et al., 2023). Companies need employees with soft skills (critical thinking, lifelong learning, adaptability) and also those with hard skills (basic programming knowledge, data management, algorithms). AI could take over many human tasks, but people need to see it as complementary to their work. This development requires fundamental knowledge and skills such as mathematics, statistics, and logic (Zupan et al., 2023). The government and universities should play a more active role in AI implementation and skills development. The government should create large-scale programs to tackle the skills gap, and the education system should introduce more fundamental AI skills and adapt faster to work with industries (Zupan et al., 2023).

3 The public sentiment towards AI technologies

Slovenians generally expressed mixed feelings regarding AI (Čater et al., 2023). The respondents primarily use virtual assistants, followed by smart household appliances, smart energy management solutions, and integrated smart security systems.

The survey showed that the sentiments toward AI express curiosity, excitement, and surprise, indicating a positive outlook for AI development. Feelings of fear and confusion are generally absent. Respondents interestingly also have contradictory views, perceiving AI as both dangerous and trustworthy, emphasising the need to reconcile this perception gap. Regarding generative AI, which caused an AI boom in 2023, respondents, on average, expressed concern about the creation of fake news. There is also worry about generative AI diminishing the value of human-generated content. However, respondents express discomfort with the idea of receiving medical diagnoses from generative AI (Čater et al., 2023). Respondents, on average, support the notion that AI systems should be supervised, that companies should ensure the development of accurate and safe AI, and that government regulation is necessary to mitigate AI risks. Collaboration between governments and companies is essential to build trustworthy systems. On average, respondents believe AI contributes to better decision-making (Čater et al., 2023).

In the future, respondents, on average, acknowledge AI as inevitable but express concern about potential job losses, contributing to the perception of AI as a threat. However, respondents are comfortable with drone or robot deliveries, followed by robot assistance at work. They are open to robots helping them in old age or disability. In contrast, respondents exhibit indifference towards medical procedures performed by robots instead of surgeons and driverless cars on busy roads. For complex and life-threatening tasks, the preference is still for human intervention (Čater et al., 2023).

The road ahead

The future of AI promises to bring transformative changes to both the economy and society. It is expected to change industries as well as have a profound impact on people's lives and work. In the business sector, AI and other technologies of Industry 4.0 are expected to significantly boost efficiency and productivity, automate routine tasks, enhance decision-making processes, and optimise operations, leading to cost savings, increased competitiveness, and economic growth. It will also impact people's lives and work. While AI can tackle high-skill tasks like machine learning and assist individuals in professional positions, it can also automate many routine tasks, leading to job disruptions for those in repetitive roles. Governments and businesses must address these challenges through retraining and upskilling programs to prepare the workforce for the changing job landscape. The future of AI is promising, but it also requires smart navigation of its integration into the economy and society in a way that benefits are balanced, considering also ethical and equity concerns. If AI technologies accelerate income inequality, the impact on future economic growth will significantly differ from what is expected.

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THE CHARACTERISTICS OF AN AI AND ICT EMPLOYMENT AND SKILLS IN SLOVENIA

Introduction

The introduction and efficient use of new Industry 4.0 technologies, including artificial intelligence (hereafter AI), require a specific set of skills and specific occupations, both on the side of those who will work directly in developing and adapting new AI tools, i.e. ICT/AI experts, as well as those whose task will be to use and work with the tools, i.e. ICT/AI users. Those who will be developing new AI-based tools will have to have specific skills and knowledge, mostly related to computing science, like programming skills, programming libraries and frameworks, machine learning, deep learning, neural networks, mathematics, statistics, natural language processing and computer vision (Raju, 2022; Verma, 2023). While developing AI tools requires one set of competencies, even adapting or using them in a specific company already requires specific additional skills. *"Probably the most in-demand skills for AI are critical thinking and problem-solving. It is not good enough to be knowledgeable in coding language and programming (...)"* (Stein & Raju, 2022). Creativity as well as soft skills will be very important as well. *"The second biggest skill is communication and the ability to communicate the strengths and weaknesses of using artificial intelligence as well as when not to use it"* (Emerick & Raju, 2022).

Those who will be using different ICT and AI-based tools more indirectly as support tools for their everyday tasks, like marketers, salespeople, accountants, and many others, will undoubtedly require specific technical and domain knowledge to understand the advantages and disadvantages of the tools and the basics about what the tool operates. However, they will primarily require critical thinking, decision-making skills, intellectual curiosity, communication abilities and emotional intelligence to efficiently convey the findings to top decision-makers (University of Leeds, 2021).

This chapter discusses the nature of AI and ICT occupations, specifically their skills and the characteristics of AI and ICT occupations in the labour market in Slovenia. The first part presents ICT and AI-occupational skills, and the second part provides selected characteristics of the occupations in Slovenia.

1 The ICT specialists, ICT users, AI occupations and their skill set

Artificial intelligence (AI) and information and communication technology (ICT) occupations are becoming increasingly important for companies of all sizes. AI and ICT are transforming how businesses operate, and companies need employees with the skills to use these technologies effectively. ICT and AI skills and, consequently, occupations that possess ICT/AI-related skills are essential for companies because they help companies adopt new technologies to use them efficiently (Green & Lamby, 2023; Liu et al., 2023), improve efficiency and productivity at the firm level, allow firms to make better decisions, develop new products and services, improve customer service, gain a competitive advantage, improve revenue flows, and stimulate changes in the labour markets (Cheatham et al., 2019; McKinsey, 2020, 2023b, 2023a).

Table 1. ICT specialists' definition with keywords describing skills

<table>
<tr><th></th><th>ISCO 2008 group</th><th>Specific skills: keywords</th></tr>
<tr><td>ICT managers</td><td>133 Information and Communication Technology Managers</td><td rowspan="4">information
system
data
development
management
techniques
analysis
project
security
communication</td></tr>
<tr><td>ICT professionals</td><td>25 Information and Communication Technology Specialists
251 Software Developers and Analysts
252 Database and Computer Network Specialists
2434 Sales Specialists of Information and Communication Technology Products and Services</td></tr>
<tr><td>ICT technicians</td><td>35 Information and Communication Technicians
351 Information and Communication Technology Technicians and User Support
352 Telecommunications and Broadcasting Technicians</td></tr>
<tr><td>ICT installers*</td><td>742 Assemblers and Servicers of Electronic Equipment</td></tr>
</table>

* ICT installers were part of the original ILO (2006) ICT occupational group; however, they were left out here because their work primarily focuses on installing the equipment.

Source: Selection of occupations based on ILO (2006). Own analysis.

To explore the skills that companies seek by employing ICT and AI occupations, both ICT and AI occupations are defined. Table 1 classifies the ICT specialists, as suggested by ILO (2006), into four basic categories: ICT managers, professionals, technicians and installers.

To explore the skills characteristics of these occupations, ECSO competence sets (European Commission, 2022) were merged with each of the ICT occupations and text mining was applied to extract the key characteristics of this group of occupations in terms of skills using keywords (Table 1) using text mining approach, including removing stop words and stemming. The keywords, as well as competence description, show that the competencies focused on computer science and information systems. Keywords such as 'information', 'system', and 'data' show that the text is related to collecting, processing, and storing information. Keywords such as 'development', 'management', and 'techniques' show that the text is related to the development, implementation, and maintenance of information systems. Keywords such as 'analysis', 'project', and 'security' show that the text is related to the analysis, design, and security of information systems. Keywords such as 'communication' show that the text is related to the transmission of information. 'Information' is the most common keyword in the text. The word is used in the context of data collection, processing, and storage of information. 'System' and 'data' are common keywords in the text, implying that the text is related to information systems designed to collect, process, and store data. 'Development' and 'management' are also used a lot, and a deeper look at the ESCO descriptions shows that the text is related to the development and maintenance of information systems. 'Analysis' and 'project' stress the importance of the analysis and design of information systems. 'Security' is also a common keyword that shows that the text is related to ensuring the security of information systems. Overall, keywords indicate that the text analysis highlights that the skills of ICT experts of different types are related primarily to the collection, processing, storage, development, management, analysis, design, and security of information systems.

Similarly, occupations that are most likely to use AI more intensely have been studied (Table 2). The selection of occupations has followed the definition by Green and Lamby (2023), who define ten occupations where the use of AI will be most intense. They include occupations from marketing, ICT as well as even animal producers. Again, these occupations were linked with relevant occupational ESCO competencies. The analysis shows that the occupations that will use AI most intensely will need managing skills, communication and collaboration skills, problem-solving, decision-making skills, creativity and others. This selection of skills, typically used in more demanding job positions, supports the notion that AI is used primarily in more knowledge-intense occupations (Gmyrek et al., 2023).

Table 2. List of ten occupations most intensely using AI with keywords describing skills

<table>
<tr><th>ISCO occupations most intensely using AI</th><th>Specific skills: keywords</th></tr>
<tr><td>122 Sales, Marketing and Development Managers</td><td rowspan="10">management
analysis
planning
implementation
evaluation
communication
collaboration
problem-solving
decision-making
research
data analysis
critical thinking
creativity
innovation</td></tr>
<tr><td>133 Information and Communications Technology Service Managers</td></tr>
<tr><td>212 Mathematicians, Actuaries and Statisticians</td></tr>
<tr><td>211 Physical and Earth Science Professionals</td></tr>
<tr><td>213 Life Science Professionals</td></tr>
<tr><td>214 Engineering Professionals</td></tr>
<tr><td>215 Electrotechnology Engineers</td></tr>
<tr><td>251 Software and Applications Developers and Analysts</td></tr>
<tr><td>252 Database and Network Professionals</td></tr>
<tr><td>612 Animal Producers</td></tr>
</table>

Source: Occupations based on Green & Lamby (2023). Own analysis.

Some other keywords (not included in this table due to length) are highly specialised (e.g., 'liquid chromatography' and 'telescope images'), indicating expertise in specific scientific or technical domains. The terms related to environmental management and compliance suggest focusing on environmental sustainability and regulatory adherence. The list also included keywords related to gaming and gambling, which may be relevant in the context of the gaming industry or related research. In summary, the text is a compilation of keywords that represent a wide array of skills and competencies, which by far are not routine tasks but have a high component of non-routine elements, primarily those non-routine analytical tasks.

The ICT users, as is evident from the skills keywords, are mostly involved in different types of decision-making (Table 3). The keywords are generally related to business and management. There is a focus on strategic planning, leadership, and collaboration, while sustainability and compliance are also important topics. The ICT users will also require ICT-related skills. These are not among the top skills; however, keywords such as technology, data, software, computer, system, database, and programming also appear in the relevant ICT users' occupational skill sets. The most important skill set identified through the keywords also shows that the ICT users are crucial in the most important processes in the company. Indirectly, with the growing shares of ICT users, there is an increasing need for ICT specialists and other (primarily intellectual) occupations to possess ICT skills.

Table 3. ICT user occupations with keywords describing skills

ISCO ICT user occupations	Specific skills: top keywords
121 Business Services and Administration Managers	management strategy planning leadership analysis communication collaboration sustainability compliance communication collaboration policy
122 Sales Marketing and Development Managers	
134 Professional Services Managers	
211 Physical and Earth Science Professionals	
216 Architects, Planners, Surveyors and Designers	
231 University and Higher Education Teachers	
241 Finance Professionals	
242 Administration Professionals	
243 Sales, Marketing and Public Relations Professionals	

Source: Occupations based on OECD (2023). Own analysis.

2 The characteristics of ICT and AI occupations in Slovenia in the business and public sector

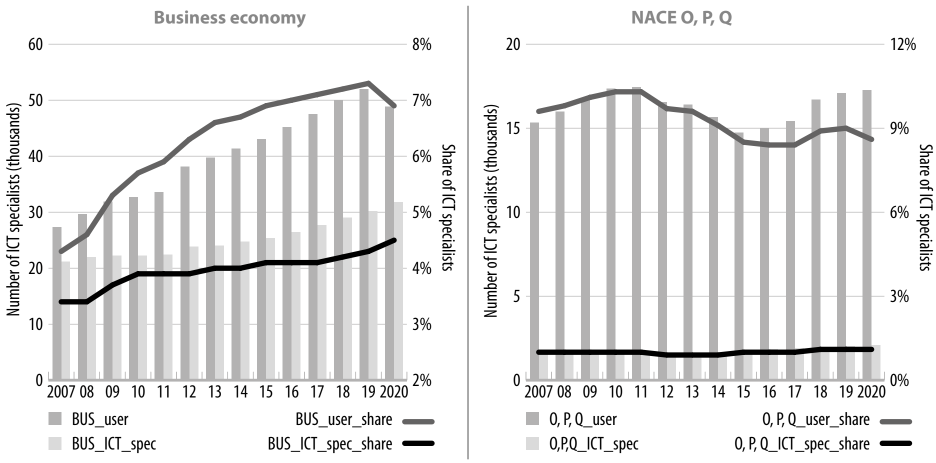
The development of a digital or intelligent economy in Slovenia will also rely increasingly on knowledge capital. Due to the increased role of ICT and AI-based technologies, the position of ICT specialists will be important. An increasing share of other occupations will also use inputs from different ICT and AI tools. Thus, the share of individuals that can be classified as ICT users or AI occupations will also be increasing. In continuing, the trends in these occupations are presented for Slovenia in the private and 'public' sectors (NACE O, P, Q).

This chapter presents the supply and demand for ICT and AI-related occupations in Slovenia, more precisely:

1. ICT specialists, who are primarily occupations in the role of developers or technical experts in the field, while
2. ICT users and AI users (Table 2) need certain skills; however, they more intensely use the outputs of ICT experts.

ICT specialists are classified as occupations ISCO 133, 215, 251, 252, 351, 352 and 742, encompassing occupations defined as ICT specialists in Table 1 (but now including assemblers). ICT users are all those occupations that increasingly use inputs prepared by ICT specialists and depend on their work. These are the following occupations according to ISCO classifications: 121, 122, 134, 211, 216, 231, 241, 242 and 243.[1] These include occupations like legislators, senior officials and managers, corporate managers, financial and insurance managers, physical, mathematical and engineering scientists, life scientists, and related professionals. With the increasing role of AI, the share of individuals who will come in contact with AI and will be most likely to use it will also increase. According to Green and Lamby (2023), the ten most exposed occupations to come in contact with AI will include occupations defined in Table 2. The analysis is prepared using the 'Statistical Registry of Employees' in Slovenia between 2007 and 2020, which provides information on the structure of employees, their education and occupation, and selected other variables.[2]

Figure 1. The number and share (of ICT specialists and ICT users in the business sector and 'public' sector (NACE O, P, Q)



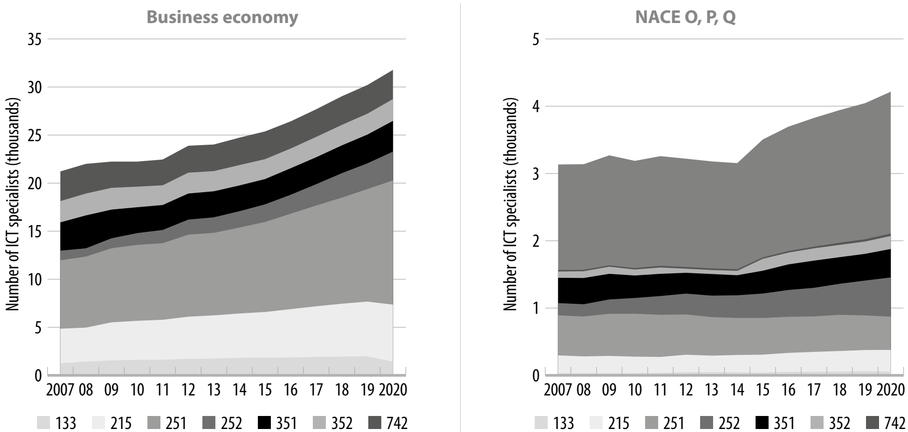
Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

1 121 Business Services and Administration Managers, 122 Sales, Marketing and Development Managers, 134 Professional Services Managers, 211 Physical and Earth Science Professionals, 216 Architects, Planners, Surveyors and Designers, 231 University and Higher Education Teachers, 241 Finance Professionals, 242 Administration Professionals, 243 Sales, Marketing and Public Relations Professionals.

2 This analysis was in the first part (ICT and AI occupations) based on the work done within project H2020 Globalinto. The GLOBALINTO project has received funding from the European Union's Horizon 2020 programme. The mechanisms to promote smart, sustainable and inclusive growth under grant agreement No. 822259. The data for this part of the analysis was prepared using the protected micro datasets of the Statistical Office of the Republic of Slovenia and the support of the User relations section of the Data publication and communication division.

Figure 1 presents the data on the number of ICT specialists and ICT users as well as their shares as a percent of total employment in the business sector and the sectors O, P, and Q, which represent public administration, education and health, typically being 'public'. The number of ICT specialists has been increasing in both the business and public sectors. In 2020, it reached close to 32 thousand experts working in ICT specialists occupations, representing around 4.4 percent of the employees. The number of ICT users increased much faster, reaching around 52 thousand in 2019 and then declining in 2020 (Covid effect). In the observed period, the share of ICT users increased from 4.3 to 6.9 (7.3 in 2020) percent of employees. In the public sector, both the share and the number of ICT users fluctuated, while the number of ICT specialists increased with a stagnant share. This trend could imply potential challenges for the public sector in the process of digitalisation and the use of AI.

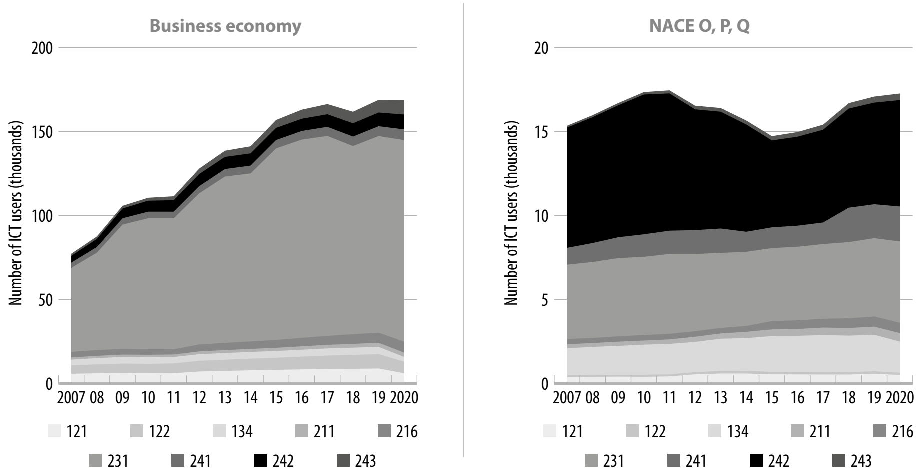
Figure 2. The number of ICT specialists by type of ICT specialist occupation in the business sector and 'public' sector (NACE O, P, Q)



Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

The structure of ICT specialists in the public and private sectors also differs significantly (Figure 2). In the private sector or the business economy, the most significant shares of ICT specialists are information and communications technology service managers (ISCO 133) and software and applications developers and analysts (ISCO 251). In the observed period, the majority of ICT specialist number growth results from the growth of this segment of professionals. In the public sector (NACE O, P, Q), the number of software and applications developers and analysts (ISCO 251) is also large, but the majority of growth resulted from the increase in the employees in two other occupations: database and computer network specialists (ISCO 252) and telecommunications and broadcasting technicians (ISCO 352).

Figure 3. The number of ICT users by type of ICT specialist occupation in the business sector and 'public' sector (NACE O, P, Q)



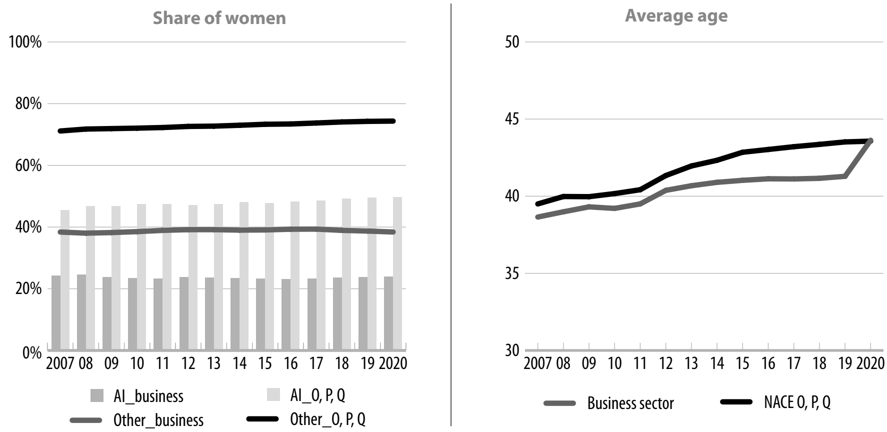
*The number of employees in occupation 231 in the private sector is too small to be visible, only around 100. ISCO codes represent: 121 Business Services and Administration Managers; 122 Sales, Marketing and Development Managers; 134 Professional Services Managers; 211 Physical and Earth Science Professionals; 216 Architects, Planners, Surveyors and Designers; 231 University and Higher Education Teachers; 241 Finance Professionals; 242 Administration Professionals; 243 Sales, Marketing and Public Relations Professionals.

Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

Among the ICT users in the business economy, the largest number of ICT users is represented by the following occupations: sales, marketing and development managers, finance professionals, administration professionals and sales, marketing and public relations professionals (Figure 3). COVID-19 impacted primarily the number of professional services managers. In the sectors O, P and Q, the largest shares of ICT users are university and higher education teachers and administration professionals.

Interestingly, the share of women between the business economy and the NACE O, P, Q differs significantly in these more technical occupations (Figure 4). Generally, the share of women in other occupations (non-AI-related) is over 70 percent in the sectors O, P, and Q and only around 40 percent in the business economy. Interestingly, in AI-related occupations (as defined in Table 2), the share of women in the NACE O, P, Q is around 50 percent. At the same time, they only represent around a quarter of AI employees in the business economy. Workers in AI-related jobs were until Covid-19 also significantly older in sectors O, P, and Q, reaching around 43.5 years. This interesting gender and age distribution could be a signal of less attractive jobs in the field in the public sector. It could again pose a risk in the process of digitalisation.

Figure 4. Share of women in AI occupations and other occupations in the business sector and public sector (NACE O, P, Q) and the average age of workers in AI occupations by sector

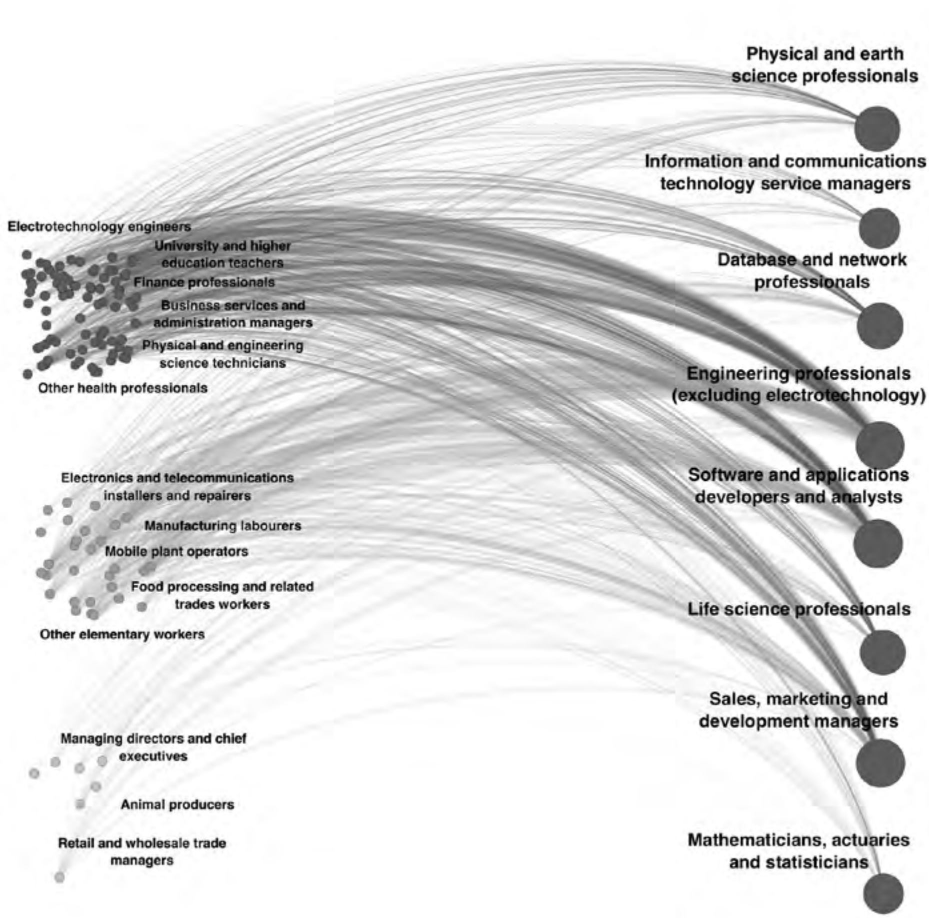


Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

From the perspective of the increasing demand for ICT and AI occupations, it is also interesting to explore the mobility into and out of these groups. Interestingly (Figures 5 and 6 for AI jobs in Slovenia), this is a very closed group with movements primarily within the specified group of occupations and very few 'outside' inflows or outflows. Due to the specific skill set, such low mobility is expected. However, from the perspective of the increasing demand in the field, this lack of mobility imposes specific challenges to companies as well as educational systems in the short run.

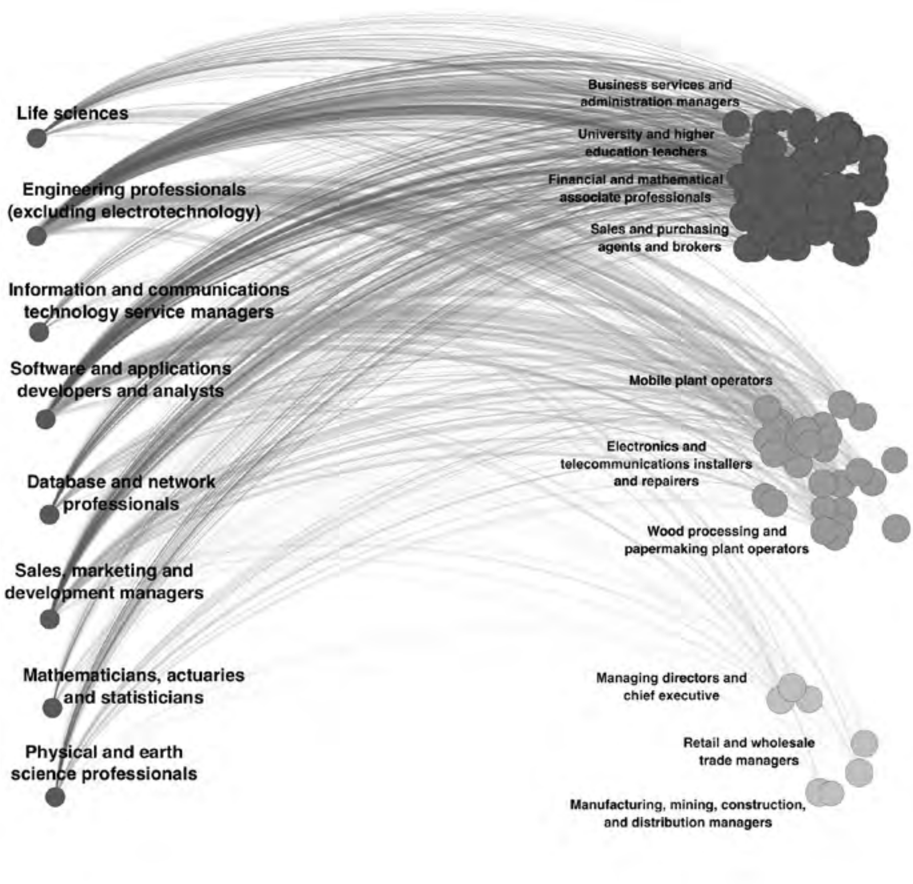
Overall, the data reveals that the demand for ICT experts and their skills (as proposed by the dynamics of ICT users) grows much faster than the employment of ICT specialists. There is also a wide discrepancy between the trend structure of both ICT users and ICT specialists between the business economy and the 'public' sector.

Figure 5. Inflow from the selected AI occupations



Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

Figure 6. Ooutflow from the selected AI occupations



Source: Statistical Office of the Republic of Slovenia (2021), own calculations.

Conclusion

The increasing use of new technologies has been changing the skills needs in the labour market in Slovenia and elsewhere. This trend is also evident from the existing labour market data in Slovenia. The analysis explored the relevant skills and employment of three groups of occupations: ICT specialists, ICT users and top AI-using occupations. The trends show that primarily in the business economy, the number of ICT users, ICT specialists, and AI-related occupations is growing fast. Despite the growing employment of ICT specialists, the gap between specialists and users is widening, which poses a specific challenge to companies and should also be a challenge to policy-makers. The 'public' sector (NACE O, P, Q) has a different trajectory of employment; however, the data reveals some weaknesses, primarily in the stagnant share of ICT specialists, which could be a challenge in the digitalisation process of these sectors.

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