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Trends in the Application of Artificial Intelligence in Hungary

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ABSTRACT

Artificial intelligence (AI) technologies are increasingly shaping economic and organisational processes worldwide, including in Hungary. This study examines current trends in the application of artificial intelligence in Hungary, with a particular focus on its role in innovation management across key sectors such as education, healthcare, public administration, and agriculture. The primary objective of the research is to assess whether the development of AI has a positive impact on these sectors and to explore the significance of AI in the innovation management of agricultural organisations. The research applies a mixed-methods approach. Secondary research is based on the analysis of domestic and international scientific literature, policy documents, and strategic reports. Primary research includes a quantitative online questionnaire survey conducted among 102 respondents working in various sectors, complemented by qualitative in-depth interviews carried out within an agricultural organisation. The collected data were analysed using descriptive statistical methods and qualitative content analysis. The results show that artificial intelligence-based solutions significantly support work efficiency, data management, communication, and decision-making processes. Most respondents perceive AI as a complementary tool that enhances human capabilities rather than replacing jobs. In agriculture, AI plays a particularly important role through precision farming, predictive analytics, automation, and sustainability-oriented solutions. The findings confirm that artificial intelligence contributes positively to innovation management, sectoral performance, and long-term competitiveness in Hungary. The study concludes that embracing AI technologies, alongside continuous skill development, is essential for organisations seeking sustainable growth and resilience in a rapidly changing economic environment.

Keywords: Artificial intelligence, innovation management, agriculture, public sector digitalisation, organisational efficiency.

INTRODUCTION

Problem Statement

Artificial intelligence-based technologies are already widespread in our everyday lives. In fact, they are everywhere today, from mobile facial recognition applications to self-driving cars. Artificial intelligence technologies are helping to overcome traditional barriers in all sectors. Among others, finance, education, healthcare and agriculture are among the sectors that use artificial intelligence. Many industries have achieved significant growth through artificial intelligence systems, and precision agriculture is also thanks to artificial intelligence. Artificial intelligence can use data to help farmers with irrigation, crop rotation, harvesting, selecting the right crops, planting and pest control.

Artificial intelligence now affects every area of our lives. Innovative technological solutions, applications that make everyday life easier, and systems that transform the economy and increase productivity are also present. However, the technologies available today are only the beginning of something new. Experts are working on developing new artificial intelligence systems that could completely transform our view of the economy and production. According to digital strategist Ágoston Hortobágyi, the value of the global artificial intelligence market could multiply by 2030, jumping from nearly $140 billion to $1.6 trillion, according to forecasts. (Világgazdaság, 2023)

RESEARCH OBJECTIVE AND METHOD

The aim of our research is to map the role of artificial intelligence in innovation management in Hungary. Furthermore, I examine the stages of its development and study the steps Hungary has taken to promote the development of artificial intelligence. Among other things, I study the fields of education, healthcare, public administration and agriculture.

My Hypotheses

H1: The development of artificial intelligence has a positive impact on certain sectors in Hungary. H2: Artificial intelligence plays an important role in the innovation management of organisations involved in agriculture.

In my thesis, I conducted both secondary and primary research. For my secondary research, I studied specialist books and scientific publications, and examined domestic and international literature and analyses available on the internet. For my primary research, I used both quantitative and qualitative research methods. For quantitative research, I created an online questionnaire. My research involved individuals working in the following sectors in Hungary: the competitive sector, agriculture, education, healthcare, and public administration. For qualitative research, I conducted in-depth interviews at an organisation involved in agriculture. Using both methods, I wanted to find out what role artificial intelligence plays in innovation management. During the data processing, I performed a descriptive analysis. I examined and summarised the results and illustrated them in text and figures using Excel.

THEORETICAL BACKGROUND OF THE STUDY

Artificial Intelligence

There is no standard definition of intelligence. Legg and colleagues (2007) presented a number of definitions covering a wide range of views. In his definition of intelligence, Gottfredson (1997) touched on several factors, including the importance of rapid learning and learning from experience. These definitions highlighted that the skills used by humans encompass a broader range of abilities than the general definitions of intelligence. One consequence of this broader range of usable skills is that it is human nature to seek the limits of one's abilities. The application of these wide-ranging abilities is what actually defines human intelligence. Given the extremely complex nature of the modern world, people strive to adapt to new situations, which requires faster and more efficient work processes, flexibility and immediate solutions. However, the work of Kahneman and his colleagues (2011) has shown that human decision-making is not always rational and often does not lead to optimal solutions. The development of human intelligence led to the recognition of the concept of artificial intelligence in the 1950s, which made it possible to program computers to behave intelligently. Through their ability to learn, humans have improved the efficiency of automated work processes. While the technological innovations that resulted from the third industrial revolution provided the foundation for the rapid development of artificial intelligence, big data and related analytics have enabled humans to further increase their level of intelligence. (Hassani et al., 2020)

Today, artificial intelligence is considered one of the main inventions of the fourth industrial revolution. Buchanan (2006) noted that artificial intelligence is not limited to robots, but rather captures the ability of computers and other technology-enabled devices to understand the nature of intelligent thinking and action. More recently, artificial intelligence has been defined as a broad field of study aimed at creating intelligent machines, as opposed to the natural intelligence exhibited by humans. Technological developments over the past two decades have built on the work of previous decades, where humanity has made technological advances, laying the foundation for the future development of machines and algorithms that are capable of creating their own consciousness for the first time in human history. In this new era of technology, humans are producing new information every second. Scientists are trying to extract useful information from the ever-increasing amount of data. Drucker, for example, described our current era as the information age or the knowledge economy. It was Engelbert who first discovered the importance of computer technologies in unleashing human creativity and capabilities. (Hassani et al., 2020)

Definition of Artificial Intelligence

The European Commission defines artificial intelligence as "a system that displays intelligent behaviour by analysing its environment, performing various tasks with a degree of autonomy to achieve specific goals." (Kacsukné Bruckner & Kiss, 2019, p. 10) The term artificial intelligence was first coined by John McCarthy at a conference in Dartmouth. The first computer programme related to it also saw the light of day that year, called Logic Theorist, which could be used to prove simpler mathematical problems. (Kacsukné Bruckner & Kiss, 2019)

Artificial intelligence essentially refers to computer systems that can perform tasks that require human intelligence.

Its development has enabled digital devices to perceive their environment, understand problems, and make independent decisions. (Kökény & Miskolczi, 2022)

According to Fantinuoli's view, artificial intelligence is a subfield of computer science that examines how machines can mimic human activity. (Horváth, 2021)

Historical Overview

The concept of artificial intelligence was already present in ancient times. When reviewing ancient Greek mythology, references can be found to the creation of several humanoid robots. For example, Hephaestus made self-moving three-legged tables and created Talos, a human-shaped, self-propelled bronze structure. The definition of the modern robot dates back to the 20th century, as does the development of artificial intelligence. Among the significant works are, for example, Isaac Asimov's works related to robotics. In his work, he presented the three laws of robotics, which are still frequently referred to by experts today. To date, significant progress has been made in the field of artificial intelligence, and its areas of application have also expanded considerably. Thanks to the achievements of Industry 4.0 in the 21st century, artificial intelligence has reached a level that many experts consider to be a defining milestone in human development.

Pfohl et al. (2015) described Industry 4.0 as an innovation whose main goal is to minimise the need for human resources. Based on Yoon's (2017) approach, Industry 4.0 encompasses the coexistence of physical and virtual space. Artificial intelligence-based methods guide us towards integration between tools and people, as well as a new level of human existence. Based on Prisecaru's (2017) position, Industry 4.0 distinguishes between two areas: biological and physical innovation. Artificial intelligence uses algorithms to understand complex situations. Its applications have spread over a wider area in recent years, a prime example being Google's artificial intelligence-based search interface. (Kökény & Miskolczi, 2022)

Artificial intelligence first saw the light of day around 1950. The initial goal of artificial intelligence was to use computers to automate non-analytical human knowledge symbolic computational processes. Although initially considered a limited branch of computer science, and was limited by the capabilities of the hardware at the time, over the years, thanks to changes, it has become a vital element in the development of numerous services and industrial sectors in the 21st century. Artificial intelligence is a branch of computer science that studies algorithms for developing computer solutions that mimic the cognitive, physiological or evolutionary phenomena of nature and human beings. Unlike the traditional model, it does not require knowledge of specific paths to solving problems, but rather relies on data, solutions or the relationships between them. Currently, artificial intelligence is focused on solving problems related to large amounts of data that change over time. This type of data may contain inaccuracies and, in some cases, contradictions. Currently, function approximation systems using iterative techniques and interconnected neural network architectures constitute most of the techniques that can be classified under the terms "machine learning" and "deep learning". The field of application of artificial intelligence has expanded over the last decades and years. (Ruiz-Real, et al., 2020)

Even at its current level of development, artificial intelligence has the potential to disrupt several sectors. Today, many artificial intelligence-based methods are already present in the manufacturing industry, the automotive industry, financial services, healthcare and the entertainment industry. (Kökény & Miskolczi, 2022)

Stages of Development in Hungary

The development of artificial intelligence in Hungary has followed a similar path to that in other more developed countries. Research and innovation in the field of artificial intelligence began as early as the 1950s, but significant, decisive results have only emerged in recent decades. In the 1990s, advances in information technology opened up new opportunities in the field of artificial intelligence, and organisations began to make more intensive use of the possibilities offered by artificial intelligence. Since the 2000s, Hungary has been an active participant in European research and development. The cooperation launched in the autumn of 2019 laid the foundations for the preparation of a document called the Strategy in Hungary, which called for continuous cooperation during its implementation. The document set out a general development goal in relation to technologies, which sees an opportunity to raise the standard of living of Hungarian citizens. (Ministry, 2020)

Between 2016 and 2020, thirty countries voted in favour of a separate strategy on artificial intelligence. Among others, the member states of the European Union, the United States, Japan, China, Russia and Saudi Arabia were involved. In Hungary, the national strategy for the period up to 2030 was published in September 2020. The primary goal of the national strategy is to ensure that at least one million people have well-paid jobs with the help of artificial intelligence by that date. Another key element of the strategy is the importance of raising social awareness. The National Data Asset Agency, responsible for managing Hungary's data assets, began its activities at that time, followed by the launch of the National AI Laboratory, which focuses on AI-related R&D and innovation, as well as data analysis. (Fundamental Law, 2023)

Artificial intelligence research is currently one of the most dynamically developing and promising fields of science. Known areas of application for artificial intelligence include expert systems, speech recognition, natural language processing, robot technology, image processing and neural networks. (Kacsukné Bruckner & Kiss, 2019)

A basic example of the everyday application of artificial intelligence is the operation of chatbots, which have significantly simplified the work of customer service employees at several large companies.

Chatbots are already being used in banking today; we can book appointments, place and modify orders, and manage our social media accounts. In many cases, artificial intelligence chat is also used in customer relations. Chatbots can filter out the essence of what the customer is saying in a matter of seconds, then ask appropriate, easily understandable questions and automatically complete the transaction process. In customer service, we can now only discuss matters in person, verbally, in special cases when we want to deal with a particular issue. In fact, this solution is only necessary when artificial intelligence cannot find a solution to the problem at hand. Artificial intelligence is also part of everyday life, for example, when using machine translation, searching the internet, or using personal assistants on smartphones. (Pénzcentrum, 2023)

The Effects of Artificial Intelligence on Individual Sectors

A milestone in the field of artificial intelligence was reached when Turing presented the Turing machine (1937), an intelligent computer model that developed automata theory. Artificial intelligence has undergone three waves of research so far. The first wave was confronted with the limited computing capacity and processing power of computers. the second wave saw the development of artificial neural networks that function similarly to the human brain and computers with better computational capacity, and the third wave of research, which is now dominant, is driven by deep learning. In terms of its application, artificial intelligence is still lacking in certain areas. Artificial intelligence can help free up government labour, as it has enormous potential in various government sectors such as education, infrastructure, transport, telecommunications, data security, finance, healthcare, research and development, decision-making, and the legal and judicial systems. In the healthcare sector, for example, innovative health monitoring devices such as heart rate, oxygen level, blood pressure and motion sensors are connected to remote systems that allow the health of elderly people to be monitored from home or hospital. For public safety, networked cameras can be used on roads, in hotels, shopping centres or any other public place to identify, track and monitor criminals.

In the transport sector, technologically advanced vehicles can be manufactured with built-in GPS, voice assistants and real-time traffic information to plan routes in advance and avoid road accidents. In addition, it can also be used in other areas, such as commerce, banking and telecommunications. (Sharma, et al., 2020)

Education

Between 2020 and 2030, there have already been significant changes in the application of artificial intelligence. In the field of education, algorithms and machine learning will transform the processes of teaching and learning. As a result, there will also be changes in the relationship between students and teachers, as well as between students

themselves. In addition, it will become commonplace in society to continuously develop skills related to constantly evolving technology. In the field of education, the processing of large amounts of information with the help of artificial intelligence makes it possible to identify areas of literacy that will help launch training programmes that meet today's needs. Power will be concentrated in the hands of those who not only have access to data, but are also able to process it. In the future, not only universities but also secondary schools will offer massive online courses to their students. Artificial intelligence can serve not only the interests of institutions but also those of students. No two students have the same learning style, just as no teacher can devote attention to the individual needs of every student in a classroom at all times. Education tailored to individual needs is already present in education, and within the framework of the digital pedagogy system, it is likely to become increasingly effective. The advantage of interactive e-learning systems is that they identify the shortcomings of individual students and can focus on specific areas when imparting knowledge. The development of these systems is only just beginning to take root in public education. Artificial intelligence plays a significant role not only in reducing costs, but also in providing a personalised learning experience. Today, artificial intelligence is already being used to map out individual learning paths, for example through the Cram101 programme, which uses interactive textbooks for certain subjects. The use of information and communication tools in education overshadows the personal relationship between teachers and students. Based on the above, there will be a need for humanisation in digital pedagogy, as there is a great need for interaction.

As far as possible, great emphasis must be placed on communication in the digital environment. One tool for this could be blended learning, which combines the opportunities offered by the internet and digital media with classroom teaching. (Szűcs, 2020)

Healthcare

The development of artificial intelligence gives cause for optimism in all areas of healthcare, from diagnostics to treatment, and could represent a significant step forward. There is already ample evidence that artificial intelligence algorithms perform as well as or possibly better than humans in various types of tasks, such as analysing medical images or correlating symptoms and biomarkers from electronic medical records with disease characterisation and prognosis. Demand for healthcare services is constantly growing, and many countries face a shortage of healthcare professionals, especially doctors. Healthcare institutions also face the challenge of keeping pace with new technological developments. The development of wireless technology and smartphones has created opportunities for on-demand healthcare services, just as condition monitoring applications and search platforms have enabled a new form of healthcare that is accessible anywhere and anytime through remote interactions. Such services are particularly relevant in underdeveloped regions and areas struggling with a shortage of specialists. Telemedicine is also relevant in developing countries where the healthcare system is expanding and where healthcare infrastructure can only be planned to meet current needs. According to experts, artificial intelligence can improve any process in the functioning of healthcare. According to forecasts, artificial intelligence applications could reduce annual healthcare costs in the United States by $150 billion by 2026. Artificial intelligence-based technology will play an important role in maintaining people's health through continuous monitoring and coaching, providing personalised treatments and more effective follow-up for people. The healthcare market related to artificial intelligence is expected to show a rapidly growing trend. Over the past decade, there have been numerous technological advances in the fields of artificial intelligence and data science. Although research into artificial intelligence for various applications has been ongoing for decades, current research differs from previous efforts.

The perfect combination of increased computer processing speed, larger data collection libraries, and a large pool of artificial intelligence talent has enabled the rapid development of artificial intelligence tools and technology in the healthcare field. (Bohr & Memarzadeh, 2020)

Many companies are exploiting opportunities in this area, including IBM Watson and Google Deep Mind, which have demonstrated that artificial intelligence can outperform humans in certain tasks and activities, including chess and other games. Both IBM Watson and Google Deep Mind are currently being used in a number of healthcare applications. IBM Watson is used in the treatment of diabetes, cancer, and drug research. Deep Mind applications are also being explored, including mobile medical assistants, medical imaging-based diagnostics, and patient condition prediction. In general, it is believed that artificial intelligence tools facilitate and improve human work, but do not replace the work of doctors and other healthcare personnel. Artificial intelligence is ready to support healthcare staff in everything from administrative workflows to clinical documentation and patient outreach, as well as providing specialised support in areas such as image analysis, medical device automation and patient monitoring. There are different opinions on the positive applications of artificial intelligence in healthcare. In 2018, Forbes reported that the most important areas would be administrative workflows, image analysis, robotic surgery, virtual assistants and clinical decision support. According to a 2019 report by McKinsey, important areas include connected and cognitive devices, targeted and personalised medicine, robotics-assisted surgery and electroceuticals. (Bohr & Memarzadeh, 2020)

Public Administration

Digitalisation is also becoming increasingly important in the public sector. Every day, more and more tasks can be carried out online, thanks to artificial intelligence solutions. Nowadays, hybrid chatbots answer our questions. The magyarorszag.hu portal also uses artificial intelligence to operate administrative points that help people with their administrative tasks. Robotic developments and e-government services are helping to serve customers on an increasingly wide scale.

The primary goal of the government is to ensure that experiences and opinions regarding public administration are more positive in the future and that Hungarian citizens are more satisfied. In today's digital world, it is a natural expectation that public administration should also have a telephone and electronic customer service that guarantees high-quality customer service. In the spring of 2021, the Digital Hungary Agency launched the MIA hybrid chatbot, supported by artificial intelligence. The chat application combines artificial and human intelligence to answer questions that arise. In addition to interactive, written communication, the MIA chatbot can also convert live speech into written text. Since its inception, the MIA chatbot has answered questions from more than 800,000 customers. More than 30% of the questions were handled automatically by the robot without human assistance, and 60% were answered semi-automatically. MIA currently provides assistance to people in the Customer Portal application. Over the past few years, the state has launched a number of identification methods, of which the Customer Portal is well known. New for 2022 is the Client Gateway+, i.e. enhanced two-factor identification. At the beginning of 2021, facial recognition using artificial intelligence and video technology was launched, allowing people to conduct their business via video channel. With facial recognition, almost all types of administrative tasks can be performed from a computer or smartphone. Comparing the results of the first half of 2021 with the first half of 2022, it can be said that the service generated 110% growth. During the pandemic, it was important to implement solutions that minimised personal contact, which led to the creation of MIA Pont, an artificial intelligence-supported administrative service point. The number of types of transactions that can be carried out at these points is increasing day by day. Today, there are approximately 200 MIA Ponts in Hungary. Their use is likely to become part of everyday routine, just like using an ATM. In the near future, the MIA chatbot is expected to undergo a significant expansion of its tasks in terms of video communication services. (Portfolio, 2022)

Agriculture

Agriculture is a sector that encompasses science, engineering studies and their economic derivatives. Artificial intelligence has also taken hold in the agricultural sector. Numerous studies have addressed this topic; for example, McKinion and colleagues provided a comprehensive overview of the use of deductive techniques based on expert systems in agriculture.

Other studies have highlighted the use of expert systems and decision support systems for process simulation and supply chain management. Furthermore, artificial intelligence is also used in quality control processes. In recent years, there has been growing interest in the application and versatility of artificial intelligence in the agricultural world, as it has proven to be an effective tool for data analysis. The expansion of industrial and technological agriculture has increased production, meeting the growing demand for richer and more resource-intensive diets. Industrial agricultural activities have also created jobs, improved economic growth and boosted the service sector in industrial regions. Agriculture 3.0 brought robotics and automation to the world of agriculture, as evidenced by agricultural machines that perform entire cycles of agricultural work, such as planting, spraying and harvesting. Now Agriculture 4.0 is on the horizon, which, in addition to smart farms and the interconnection of machines and systems, aims to adapt production ecosystems by optimising the use of water, fertilisers and plant protection products. Combined with genetic engineering and data utilisation, agriculture can play an important role in maximising resource efficiency and adapting to climate change and other challenges. To this end, the use of big data in decision-making is essential. The integration of agricultural technology and Industry 4.0 concepts by agri-food companies has also sparked greater interest in artificial intelligence. (Ruiz-Real, et al., 2020) Agriculture is arguably one of the world's oldest and most important industries.

The world's population is growing, and with it, the demand for agricultural products. As a result, new automated methods are being introduced to meet food needs, as the traditional methods used by farmers are insufficient to meet these requirements. In addition, this provides job opportunities for billions of people worldwide. Farmers are forced to look for new solutions due to labour shortages, stricter regulations, global population growth and a decline in the number of farmers. Technologies such as the internet and artificial intelligence are becoming established in almost every industry. Numerous studies are being conducted to improve the quality and quantity of agricultural products, for example through smart farming. Farmers can also use artificial intelligence as part of precision farming .

Farmers need to accurately identify and classify crop quality characteristics in order to increase product prices and reduce waste. With the help of data, machines can detect and reveal new characteristics that contribute significantly to crop quality. Water management in agriculture has a significant impact on agronomic, climatological

and hydrological balance, and applications also enable more efficient use of irrigation systems. Farmers are increasingly using artificial intelligence models to increase productivity, and it can be said that the food technology sector has benefited most from this technology. Robots and sensors are currently used to manage and monitor crops and collect crop-related data. Artificial intelligence is developing rapidly. Agriculture is one of the areas that has already begun to exploit the benefits of artificial intelligence, whether it be weed control, calculating the best time to harvest crops, monitoring soil and crop health, or forecasting yields. Farmers in particular can make better decisions thanks to artificial intelligence technology, which leads to increased efficiency in crop production and animal husbandry. Artificial intelligence systems predict weather patterns, assess crop health, and detect diseases, pests, or insufficient nutrient uptake by plants. Farmers can use artificial intelligence-powered drones to monitor the health of their crops. Experts examine the images taken by the drone and prepare a report on the condition of the farm. This helps farmers control pests. Some farmers now use agricultural robots to perform more time-consuming and difficult physical agricultural tasks. These robots can save farmers money and reduce the workload of their employees. (Javaid, et al., 2023)

The main goal of research in the field of artificial intelligence is to reproduce human intelligence in robots that mimic human behaviour, including learning and problem solving. Experts are researching artificial intelligence technology to solve problems related to agricultural productivity.

Artificial intelligence technology can, for example, help farmers increase crop yields by assisting them in selecting the right crop varieties, applying better soil and nutrient management practices, managing pests and diseases, estimating crop yields, and forecasting raw material prices. Artificial intelligence in the agricultural sector uses robots, image processing, wireless sensor networks, machine learning and other cutting-edge methods to address agricultural challenges. These artificial intelligence technologies can already help farmers monitor their farms in real time, for example, weather, water use, or soil conditions, so they can make more informed decisions. Artificial intelligence is used to develop smart farming practices that reduce farmers' losses while ensuring high yields. (Javaid, et al., 2023)

The Bonafarm Group, for example, uses artificial intelligence-based solutions in agriculture and the food industry, as well as in its services. In the dairy cattle sector, for example, there is a system that can determine whether an animal is sick based on its movements. Thanks to this, appropriate care can be provided immediately in the event of a health problem. In the food industry, a pig counting system operating in slaughterhouses greatly assists the work of employees. In corporate IT services, artificial intelligence is used in virus detection and spam filtering systems. (Portfolio, 2023)

Innovation Management

Definition of Innovation Management

"Innovation management is the systematic process of organising innovative solutions across the entire enterprise." (Deák, 2023, p. 1)

Innovation management is a complex concept that encompasses the complex renewal of an organisation's knowledge, qualities, products, services and manufacturing methods. "Innovation management is the driving force behind the value creation process in businesses." (Piskóti, 2016, p. 12)

The foundations of the innovation management system have been built in such a way as to facilitate the effective implementation of innovation activities. These principles help organisations recognise how innovation can be a source of value creation. Value creation is the goal that drives organisations to engage in innovation activities. In many cases, innovations result in a complete transformation of current operations. The value created through innovation is measured by financial indicators. The potential benefits of value creation include the following:

- contributing to the organisation's competitive advantage
- increased effectiveness of innovation
- improved reputation
- legitimate innovation activities
- support for the creation of an organisational culture that supports innovation. (Csizmadia, 2023)

Overview of the Development and Application of Artificial Intelligence in Innovation Management in Hungary

Innovations are generally implemented by countries through a well-established institutional framework. The task of the national innovation system is to support scientific and technical development in economic processes. The national innovation system encompasses organisations and institutions involved in knowledge creation, research and the support of government innovation policy. Its central elements include, for example, the education system, research, the legal system governing the economy, and the infrastructure, resource and financing systems

for innovation. In a broader sense, the system includes all organisations and structures in the business sector that contribute to the creation and dissemination of knowledge and to increasing the country's competitiveness. (Csizmadia, 2023)

Employee skills supplemented by artificial intelligence can be beneficial to Hungarian companies from many perspectives, as they offer a way to work faster and more accurately. The AI Strategy also contributes significantly to the strategy of strengthening domestic micro, small and medium-sized enterprises. The AI Coalition has published a domestic labour market survey according to which the spread of artificial intelligence-based technologies could affect as many as 900,000 Hungarian jobs by 2030.

This figure represents a quarter of current jobs. In the best case scenario, systems using artificial intelligence only complement and reinforce the skills of employees, thereby increasing efficiency. Between 2018 and 2019, the European Union developed a document entitled "European Coordinated Plan for the Development of Artificial Intelligence", which it recommended to all Member States ( ). In early 2020, the European Commission published a white paper examining the expected regulatory framework for artificial intelligence in Europe. (Ministry, 2020)

There are currently several initiatives using artificial intelligence in Hungary, such as chatbot-based customer service, precision farming applications, inventory forecasting and health diagnostics. The retraining and further training of employees will be one of the main challenges for the labour market by 2030. There is a wide range of applications for artificial intelligence, many of which are already in use or planned in Hungary. The list below shows the areas of AI projects that have already been launched or are in progress in Hungary:

- Telecommunications
- Banking and insurance
- Retail
- Transport and logistics
- Manufacturing
- Agriculture
- Energy
- Health
- Public administration. (Ministry, 2020)

Artificial intelligence also has a significant impact in our country, where it is present in numerous industries, such as agriculture, where it plays an important role in certain automation processes. It is also significant in technologies that effectively increase production, including the analysis and use of data collected by drones and satellites. It is used to monitor and optimise crop conditions, soil quality and other important factors, and is also significant in the analysis of agricultural data. With the help of forecasts, farmers can make more efficient production decisions, and artificial intelligence-based systems can help in the selection of fertilisation and irrigation strategies.

They are able to make recommendations based on data regarding the most suitable production practices for soil types and plant varieties. In terms of increasing fertility, AI-based systems can help optimise production processes, for example in plant protection and harvesting. In addition, intelligent systems can also be used to manage plant diseases more effectively. It can also have a significant impact on healthcare, helping to improve the accuracy of diagnostics and the effectiveness of treatment, and playing an important role in drug development. In Hungary, there has been continuous development in this area with regard to the application of artificial intelligence. In the field of medical diagnostics, for example, imaging techniques are also very helpful in the analysis of CT or MRI scans. It is essential for doctors to make more accurate diagnoses and develop treatment plans. The information obtained from the data can help predict the spread of diseases and make more efficient use of healthcare resources. It plays a significant role in the education system, particularly in the tasks to be performed by higher education. The automation of administrative processes with the help of artificial intelligence, the development of chat-based digital one-stop administration, correspondence, chat and telephone customer contact processes, the expansion of the number of customers covered by self-service process automation, the further development of the Central Identification Agent, creating the possibility of administration via KIOSKS and physical robots at in selected customer areas, developing automatic decision-making functions, supporting the online labour market and competence-based mediation. Developing systems to support the supervision of financial and tax processes, making ÁSZ, NAV and banking supervision processes more efficient by pre-screening items to be examined and introducing process automation. Artificial intelligence is a technology with enormous potential in public administration. The application of these technologies serves to increase the efficiency of public administration, promote innovation and improve services. (Ministry, 2020)

Measures and Strategies Introduced in Hungary to Promote the Development of AI in the Field of Innovation

The Hungarian Government has recognised the potential benefits of technology for the economy and society. For this reason, it has taken stock of the potential challenges involved and decided to implement a comprehensive Artificial Intelligence Strategy. The document sets out objectives for 2030 and a related action plan for 2025.

The main objective of the measures was to increase the growth potential of the Hungarian economy and consciously improve its efficiency. On the one hand, this was to be achieved through the application of existing artificial intelligence technologies and, on the other hand, through the development of future technologies. The strategy also paid special attention to promoting the most effectively developable specialist systems using artificial intelligence-based methods, including in the fields of manufacturing, agriculture, healthcare, public administration, logistics, transport and energy. Over the past decade, artificial intelligence as a technology has undergone such rapid development that in many cases it has been compared to the beginning of a new industrial revolution. In this case, however, development does not require natural resources, but rather the limits of development are set by the competence of existing human resources. This technology affects everyone personally, reshapes the expectations of the labour market in detail, opens up new dimensions in terms of increasing efficiency, and can also generate significant economic growth opportunities. However, development takes place in a universal competitive environment, which may raise a number of sovereignty issues. For our country, this is both a historic opportunity and a significant challenge. (Ministry, 2020)

According to experts' forecasts, approximately 40% of jobs can be automated. At the same time, new jobs will also emerge thanks to artificial intelligence. The employees who may be negatively affected are skilled workers and unskilled workers, whose jobs are likely to be completely transformed during the third wave of autonomy. Artificial intelligence can create a new level of productivity for employees and processes, which could also mean outstanding economic growth. According to forecasts, labour productivity could improve by more than 40% by 2030. This could lead to significant investments. In addition to the introduction of technologies already in use, opportunities to support the future are available in Hungary in the areas of the ecosystem, regulation, infrastructure and the public sector. It is expected to find its way into our everyday tools, transform business processes and have a significant social impact. According to the Strategy, focusing on the available competitive advantages and taking them into account, businesses that will create the jobs of the future must be established in developing industries. There are excellent opportunities for the application of artificial intelligence-based technologies in less digitised sectors as well.

The Strategy sets out the goals of process-driven smart manufacturing using artificial intelligence at small, medium and large enterprise levels, the implementation of new business models, and the fulfilment of special requirements, which will be achieved through environmentally conscious manufacturing technologies. A further objective is to work in harmony and cooperation with stakeholders to make conscious use of the health data assets present in our country, which are expanding day by day, to increase the use of artificial intelligence in diagnosis and treatment, and to develop artificial intelligence-supported medical decision-making and medical technology tools. All of this could contribute to an efficiently functioning healthcare sector, in line with the European e-Health strategy. In addition to the above, the Strategy also aims to implement and disseminate artificial intelligence-based developments that promote the digital revolution in the agricultural sector. A further objective is the full electronic implementation of public services and support for their digitisation, in which artificial intelligence is likely to be one of the technologies currently in use. (Ministry, 2020)

The following areas already use artificial intelligence-based technologies, but forecasts indicate that further developments are expected in the future.

In agriculture, for example, autonomous control of agricultural machinery, identification of crop problems by drones, identification of sick animals with cameras, weight estimation, and automatic feeding based on the assessment of animal needs are already present today. In healthcare, for example, mammography images are analysed to detect diseases, identify medication needs and analyse national health patterns. In public administration, AI is used, for example, to identify users, provide self-service government services, enable online administration through expert systems, prevent crime, and provide cyber security protection using AI algorithms. (Ministry, 2020)

Another breakthrough in this field came with the introduction of an AI robot called ChatGPT. The technology is evolving and changing day by day, and ChatGPT is currently considered to be the most advanced artificial intelligence. The emergence of this new artificial intelligence could be as pivotal a moment in development as when Jobs unveiled the first iPhone in 2005. Artificial intelligence is permeating the entire economy, with changes being felt in factories, finance and agriculture. Modern agriculture today uses a host of new solutions that would have been unimaginable a few decades ago. Drones are no longer a novelty on farms, just as various sensors used in crop areas facilitate precision farming.

The above-mentioned technologies play a significant role in enabling farmers to monitor crop growth. They can also monitor soil conditions, allowing them to take timely action if more water or nutrients are needed. In addition, farm workers can see a realistic picture of pathogens and pests. This is essentially the basis of precision crop production. The use of agricultural robots is radically changing perceptions of agriculture. The sector is confident that these methods will enable robots to compensate for labour shortages, especially in areas requiring manual labour, such as horticulture. International studies have reported that four-armed robots designed for fruit harvesting are able to harvest crops efficiently and without damage. The prototype has already been unveiled, and experts believe that farmers will be able to use the robots widely within ten years. (Világgazdaság, 2023)

RESEARCH

Research Methodology

The aim of our research was to map the role of artificial intelligence in innovation management in Hungary. I also examined the stages of its development and studied the steps Hungary has taken to promote the development of artificial intelligence. Among other things, I studied the fields of education, healthcare, public administration and agriculture.

In the first part, I conducted secondary research, reviewing the literature on the subject and learning from specialist books and publications about how artificial intelligence has gained ground in Hungary and in specific industries. In the next part, I conducted primary research, for which I created my own online questionnaire and interview. I then processed the questionnaire responses, which I illustrated with text and diagrams. I also processed the responses to the interview questions and evaluated them in text form.

My Hypotheses

H1: The development of artificial intelligence has a positive impact on certain sectors in Hungary. H2: Artificial intelligence plays an important role in the innovation management of organisations involved in agriculture.

For my primary research, I used Google's own questionnaire system to compile my own questionnaire. I asked questions that would naturally have an impact on the topic of my thesis. The questionnaire contained twelve questions, consisting of several types of questions, including multiple choice questions and questions where respondents could briefly express their thoughts in their own words. A total of 102 people participated in the questionnaire survey. I conducted the survey between 11 and 20 March 2024. I evaluated the results of the questionnaire using Microsoft Excel.

Quantitative Research

As part of the quantitative research, I conducted an online questionnaire survey, which yielded the following results.

Women were overrepresented in the survey. Women accounted for 61% of respondents, while men accounted for 39%.

In terms of age, it can be said that a significant number of people from all age groups participated in the survey. Seventeen per cent of respondents were aged 18-30, 25% were aged 31-40, 29% were aged 41-50, and 12% were aged 51-60. Those over 60 were also active participants in the research, accounting for 17%.

Based on the distribution of participants in my research by place of residence, it can be said that city dwellers are overrepresented. 54% of city dwellers, 27% of rural and village dwellers, and 19% of capital city dwellers participated in the survey.

Based on the distribution by educational attainment, it can be said that those with university/college degrees were overrepresented. Those with university or college degrees accounted for 58% of the survey participants, those with vocational secondary school or grammar school degrees accounted for 37%, and those with primary school degrees accounted for 5%.

In terms of the sectors in which the respondents work, the competitive sector came first with 36%, followed by public administration with 24%, agriculture with 10%, education with 8% and healthcare with 7%.

Furthermore, 15% worked in other areas, i.e. not in the sectors listed above.

In terms of job classification, white-collar workers were overrepresented in the survey. White-collar workers accounted for 67% of respondents, blue-collar workers ( ) accounted for 16%, and managers accounted for 18%.

According to respondents, artificial intelligence-based methods play a significant role in their work. 61% of those surveyed believe that it makes their work easier. Only 11% of survey participants believe that it does not make their work easier. Twenty-eight per cent of respondents were unsure about this question.

Artificial intelligence-based methods increase efficiency, according to 73% of respondents. Only 2% of respondents believe that artificial intelligence does not increase work efficiency. 25% of respondents were uncertain about this question.

Those who believe that artificial intelligence-based methods have a positive impact on the sector/organisation are overrepresented in the survey, at 70%. Those who believe that it does not have a positive impact on the sector/organisation accounted for 6% of the survey. Twenty-four per cent of respondents were uncertain about the question.

In the questionnaire, respondents were asked to briefly answer the next question about the activities in which artificial intelligence helps them. According to the respondents, artificial intelligence was most helpful in communication, data management, registry maintenance, translation, and diagnostics.

Systems that use artificial intelligence only complement and reinforce employees. 67% of respondents agreed with this statement. 6% of respondents disagreed with the statement. 27% of respondents were uncertain about the question.

Twenty-two per cent of respondents believed that the growing range of artificial intelligence-based methods threatens their current job/position. At the same time, 61% of respondents believe that the growing range of artificial intelligence-based methods does not threaten their current job/position. Seventeen per cent of respondents were uncertain about this issue.

Qualitative Research

My first question was about how long the organisation had been operating. My interviewee told me that the company had started operating in 1972. My next question was about whether artificial intelligence-based methods were also used in agriculture. Dániel reported that artificial intelligence-based methods are, of course, also used in agriculture. In fact, they have gained ground in recent years, for example among agricultural machinery manufacturers, and they also help farmers and growers solve various problems. My next question was therefore about the areas in which they are most commonly used. My interviewee said that the target group of companies typically uses artificial intelligence in the following areas: among other things, they favour data-based decision-making, data management and analytics. Furthermore, artificial intelligence enables farmers to make the right decisions after processing large amounts of input data. To this end, last year the group purchased digital tools from an organisation that is currently the market leader in farm management information technology. This acquisition further strengthened the group's data management offering. The group focuses on integrated grain storage and conditioning . Artificial intelligence improves data analysis for efficient grain handling, including monitoring storage conditions, forecasting grain quality and optimising handling processes.

The joint venture between the group and Trimble, resulting from the 2023 acquisition, aims to create a global precision platform with a mixed fleet.

This includes developing a full range of autonomous solutions for every stage of the production cycle by 2030, including artificial intelligence-driven technologies for planting, harvesting and other agricultural operations. The tools developed by GSI combine and analyse data points, allowing farmers to seamlessly manage their entire farming operations. Artificial intelligence helps interpret the accumulated data, improving decision-making and efficiency. The company uses artificial intelligence to monitor crop health and detect diseases, pests and nutrient deficiencies. Drones and sensors equipped with algorithms provide real-time insight for timely interventions. In addition, it can improve logistics, inventory management and distribution within the agricultural supply chain. The company and GSI are researching ways to streamline processes and ensure that fresh produce reaches consumers efficiently. The company's primary goal is to predict climate patterns, crop yields and market trends using artificial intelligence models. This helps farmers to plan and adapt to changing conditions in an informed manner. Powered by artificial intelligence

Systems also monitor animal health, track feeding patterns and optimise breeding practices. In which activities are artificial intelligence-based methods used? I asked my next question. GSI (Grain Systems) uses artificial intelligence in various areas of grain management, as illustrated by the following examples GSI's innovative system allows farmers to monitor grain moisture, temperature and inventory 24 hours a day, seven days a week. By using artificial intelligence, farmers get real-time data and insight into their grain storage systems, enabling them to make the best possible decisions about grain storage, rotation and conditioning. The group effectively integrates machine vision into its state-of-the-art optical sorting machines, which use high-resolution cameras and built-in Cimbria BRAIN software to sort and select different seeds with high efficiency.

In addition, GSI uses machine learning models to improve the process of early detection of plant diseases. These models contribute to improving grain safety and the sustainability of the agricultural ecosystem. In this context, my question was whether robots and sensors are used to handle and monitor crops, for example.

Dániel explained that GSI uses several different sensor technologies to monitor grain storage conditions, such as temperature, humidity and moisture levels. These sensors help prevent grain spoilage, mould and insect

infestation by alerting farmers in good time. In addition, the sensors monitor grain quality during storage, ensuring optimal conditions for long-term storage. The above-mentioned sensors are integrated into grain storage facilities that contain additional automated systems to regulate air flow, temperature and humidity. These systems optimise grain quality by preventing hot spots, minimising condensation and maintaining consistent storage conditions. Some advanced systems also adjust parameters based on real-time data, ensuring the perfect storage environment. On the user side, there are remote monitoring solutions that allow farmers to monitor their grain storage facilities from their smartphones or computers. These systems provide alerts, historical data and control options, enabling proactive management away from the storage site. My next question was to find out whether my interviewee thought that artificial intelligence-based methods made his daily work easier. In Dániel's opinion, the use of artificial intelligence-based methods visibly and measurably improves the working conditions and performance of agricultural workers. By automating labour-intensive activities, artificial intelligence reduces the physical strain on agricultural workers. A good example of this is the artificial intelligence-supported predictive maintenance system for agricultural machinery equipped with sensors, which makes individual inspection work more predictable and cost-effective. My next question was aimed at finding out whether, in addition to helping with work, artificial intelligence-based methods also increase efficiency, in his opinion. My interviewee pointed out that yes, of course they increase efficiency, which is why the company has begun to exploit the potential of artificial intelligence to increase agricultural efficiency in recent years and will certainly place even greater focus on this in the future. As discussed above, the entire agricultural value chain offers various smart solutions in the areas of planting, irrigation, fertilisation, pest control, grain storage and animal husbandry. In addition to all this, he is also interested in whether, in his opinion, artificial intelligence-based methods reduce costs/expenses for the organisation.

According to Dániel, the use of artificial intelligence-based methods definitely contributes to cost savings for agricultural operators. Considering one of the largest fixed costs in the livestock industry (feed production and transport), artificial intelligence improves feed production scheduling by taking into account parameters such as feed storage stocks, consumption rates, consumption sequences and composition criteria. This ensures that the right feed is produced at the right time, in the right quantity and quality. In light of the above, I wanted to know whether, in his opinion, artificial intelligence-based methods have a positive impact on the sector. According to my interviewee, artificial intelligence is playing an increasingly important role in agriculture and offers innovative solutions for increasing productivity, sustainability and efficiency. Artificial intelligence-based methods are revolutionising agriculture by making it more sustainable, efficient and resilient. A very important aspect is the affordability and accessibility of systems and products integrated with artificial intelligence, both of which are essential for their widespread adoption in developing economies. In your opinion, do systems that use artificial intelligence merely complement and empower workers, or do they also replace them? I asked my next question. Dániel finds it exciting to consider how this issue will develop in the distant future, but he believes that the goal is not about replacement, but rather about complementing skills or further developing human abilities, which could even create entirely new jobs and opportunities, in addition to taking over previous functions, initiating a kind of restructuring in agricultural companies. What are your future plans for development? I asked my last question. My interviewee said that the group is absolutely committed to decarbonising agriculture. To achieve this, it is currently working on developing various technologies and setting future goals. One such forward-looking initiative is HVO (Hydrotreated Vegetable Oil), a fossil-free alternative to diesel fuel that can reduce the carbon footprint by up to 90%. But we should also mention the development of hydrogen hybrid internal combustion engines, which are also designed to promote sustainable agriculture. The merger of the group and Trimble also opens up a new platform for global agricultural machinery manufacturers and will catalyse innovation in the precision farming market for mixed fleets with its smart farming and autonomy solutions.

CONCLUSIONS

The literature studied during my secondary research, as well as the questionnaire responses and interviews conducted during my primary research, confirmed the fact that artificial intelligence plays a significant role in the economy, in almost every sector, and arguably in every organisation. Nowadays, consumer expectations and needs are higher, which makes the issue of efficiency even more important for organisations. Artificial intelligence-based methods help organisations, employers and employees to be more efficient and deliver better performance to consumers and customers. Between 2020 and 2030, there have been significant changes in the application of artificial intelligence. In the field of education, algorithms and machine learning will transform the processes of teaching and learning. As a result, there will also be changes in the relationship between students and teachers, as well as between students themselves. (Szűcs, 2020) The development of artificial intelligence also gives cause for optimism in all areas of healthcare, where it could represent a significant step forward, from diagnosis to treatment, for example in the analysis of medical images or in the relationship between symptoms and biomarkers derived

from electronic medical records and the characterisation and prognosis of diseases. (Bohr & Memarzadeh, 2020) Digitalisation is also becoming increasingly important in the public sector. Every day, more and more tasks can be carried out online, thanks to artificial intelligence solutions. Nowadays, hybrid chatbots answer our questions. (Portfolio, 2023)

Agriculture is one of the areas that has already begun to exploit the benefits of artificial intelligence. Whether it is weed control, calculating the best time to harvest, monitoring soil and crop health, or forecasting yields.

Farmers in particular can make better decisions thanks to artificial intelligence technology, which can lead to increased efficiency in agriculture and animal husbandry. (Javaid, et al., 2023)

In our research, we assumed that the development of artificial intelligence has a positive impact on certain sectors in Hungary. This assumption was confirmed, as I mentioned above, artificial intelligence has a positive impact on the industries I studied. Furthermore, my primary research also confirmed that, according to the participants in my survey, those who believe that artificial intelligence-based methods have a positive impact on the sector/organisation are overrepresented, at 70%. Those who believe that it does not have a positive impact on the sector/organisation accounted for 6% of the survey. Furthermore, 73% of respondents believe that artificial intelligence-based methods increase efficiency. Only 2% of respondents believe that artificial intelligence does not increase work efficiency. In addition to all this, my interviewee also believes that artificial intelligence has a positive impact on the performance and efficiency of sectors.

My other research question was what role artificial intelligence plays in the innovation management of companies involved in agriculture. Both secondary and primary research highlighted the fact that artificial intelligence is also significant in the field of innovation in agriculture. According to my interviewee, artificial intelligence is playing an increasingly important role in agriculture and offers innovative solutions for increasing productivity, sustainability and efficiency. Artificial intelligence-based methods are revolutionising agriculture by making it more sustainable, efficient and resilient. A very important aspect is the affordability and accessibility of artificial intelligence- -integrated systems and products, which are essential for their widespread adoption in developing economies. The merger between the company under review and Trimble will also open up a new platform for global agricultural machinery manufacturers and catalyse innovation in the precision agriculture market for mixed fleets with its smart farming and autonomy solutions.

SUMMARY

Artificial intelligence technologies are helping to overcome traditional barriers in all sectors. Finance, education, healthcare and agriculture are among the sectors that use artificial intelligence. Many industries have achieved significant growth thanks to artificial intelligence systems, and precision agriculture is also attributable to artificial intelligence. The aim of our research was to map the role of artificial intelligence in innovation management in Hungary. Among other things, I studied the fields of education, healthcare, public administration and agriculture. I conducted primary research, for which I created my own online questionnaire and interview. During my research, I sought answers to the following questions: on the one hand, does the development of artificial intelligence have a positive impact on certain sectors in Hungary, and on the other hand, does artificial intelligence play an important role in the innovation management of organisations involved in agriculture?

According to the results of our questionnaire survey, artificial intelligence-based methods play a significant role in work. More than half of the respondents believed that it makes their work easier. Only ten per cent of the participants in the survey believed that it does not make their work easier. Furthermore, 70% of respondents believed that artificial intelligence-based methods increase efficiency. Those who believed that artificial intelligence-based methods have a positive impact on the sector/organisation were overrepresented in the research. According to the respondents, artificial intelligence was most helpful in communication, data management, registry maintenance, translation, and diagnostics. Systems that use artificial intelligence only complement and reinforce employees. Nearly 70% of respondents agreed with this statement. A quarter of respondents believed that the increasingly wide range of artificial intelligence-based methods threatens their current job/position.

At the same time, more than half of those surveyed believed that the increasingly wide range of artificial intelligence-based methods did not threaten their current jobs/positions. My assumptions were confirmed, as both my secondary and primary research highlighted the fact that artificial intelligence has a positive impact on virtually every sector, including agriculture, where it plays a significant role in innovation. For this reason, innovation is also important in this field, in the sectors I have examined, in order for organisations to be competitive in the market. Furthermore, it is advisable for employers and employees to embrace innovation and be open to new technologies, as these have and will continue to have a positive impact on their efficiency and effectiveness.

In the past decade, artificial intelligence as a technology has undergone such rapid development that in many cases it has been compared to the beginning of a new industrial revolution. In this case, however, development does not require natural resources, but rather the limits of development are set by the competence of existing

human resources. This technology affects everyone personally, reshapes the expectations of the labour market in detail, reveals new dimensions in the field of efficiency improvement, and can also generate significant economic growth opportunities. (Ministry, 2020)

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