DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN LITHUANIA, LATVIA AND ESTONIA: SOME EMPIRICAL EVIDENCES

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Abstract
In the 21st century, artificial intelligence (AI) is emerging as one of the most important factors with a major impact not only on the productivity and competitive advantage of companies, transforming labour, goods and services, and capital markets, but also influencing the growth of the global economy. After describing the AI concept, the stages of its development and analysis of scientific literature, the paper explores the specificities of the AI use in 2021-2023 in companies in Lithuania, Latvia, Estonia and the EU-27 countries. It compares the share of enterprises using AI and analyses differences by size, sector, type of technology used, purpose of use and mode of acquisition. It explains the reasons that most often hinder the use of AI. The analysis shows that the share of enterprises using AI in any Baltic State was below the EU-27 level, but in some groups of enterprises the rate of change in the Baltic States exceeded the EU-27 growth rate. To ensure that the most significant changes do not go unnoticed and to provide longer-term insights, this study should be continued.

Key words: a*rtificial intelligence; Lithuania; Latvia; Estonia; EU-27.*

JEL Classification: *M20, O31, O33*

I. INTRODUCTION

Worldwide, the development of AI has been accelerating rapidly in the last two decades of the 21st century, covering more and more areas of society, from smartphone apps to smart homes, cities with smart infrastructure and self-driving vehicles. AI is being integrated into many areas of business because it helps companies to use and manage resources efficiently, to make quick decisions when processing huge amounts of information, and to perform jobs that are difficult for humans to do. According to Eurostat, in 2023, 8.8% of the EU-27 enterprises with 10 or more employees and self-employed persons was using at least one AI technology, i.e. 6.4% of small enterprises, 13% of medium-sized enterprises and 30.4% of large enterprises. In 2023, the highest share of enterprises using AI was in Denmark (15.2%), Finland (15.1%) and Luxembourg (14.4%). Companies use a range of AI technologies: content analysis of text; translation of text from one language to another; conversion of spoken language into a computer-readable format; image-based object or people recognition; assistants that interact with customers 24 hours a day; technologies that automate various workflows; and technologies that allow machines to move around physically to observe the surroundings and make autonomous decisions. The application of AI systems increases innovation, efficiency and market competitiveness. However, concerns about data security and privacy, the high cost of integrating AI solutions, and the lack of skilled staff are the main factors holding back the development of AI. In 2024, the European Parliament has agreed on its position on the EU Artificial Intelligence Act. This is the first ever legislation on artificial intelligence. It establishes a regulatory framework to ensure that AI systems are secure and comply with the law and respect the EU's fundamental rights and values.

The Artificial Intelligence Association of Lithuania was established in 2019 to strengthen the public perception of the value of artificial intelligence, its impact and its potential for use in areas of importance to society: education, culture, healthcare, environment, security, and value creation in other areas of interest to the general public.

The aim of the study is to assess the extent and characteristics of the use of AI in the Baltic States and the EU-27.

The research focuses on Lithuanian, Latvian, Estonian and EU-27 companies using at least one AI technology. As the reasons that hinder the use of AI were also analysed, the information provided by companies that are not yet using AI but are considering it was also analysed in depth.

Research methods: analysis and synthesis of scientific literature, comparative analysis and synthesis of statistical data.

Limitations of the study: the study used freely available statistics from official organisations (Eurostat?), but there were data gaps in some years.

The article is divided into four chapters. The second chapter presents a literature review: it describes the concept of AI, the stages of its development and the authors' opinions on the application of AI; the third chapter analyses the data on the extent of AI use, similarities and differences in the Baltic States and EU-27 companies; and the last chapter provides a summary of the conclusions.

II.LITERATURE REVIEW

In 1956, a two-month Dartmouth Summer Research Project on Artificial Intelligence took place at Dartmouth College of Hanover in New Hampshire, which aimed to bring together researchers from different fields to create a new area of research. In this project, researchers J. McCarthy, M. L. Minsky, N. Rochester and C. E. Shannon launched a new field of research, AI, and defined the AI concept by combining the concepts of man and machine. The focus of this area of research has been on machines that can simulate human intelligence (Haenlein, M., & Kaplan, A. (2019), Couch, J. R. (2023)). This project was followed by a strong interest in AI among researchers from different fields. The debate among researchers went beyond defining AI to classifying AI technologies and systems; selecting the objectives and methods of research in the field; identifying the potential limits of AI and its potential for integration into people's daily lives and activities; and assessing the positive and negative aspects of AI.

The historical evolution of AI is presented in Figure 1.

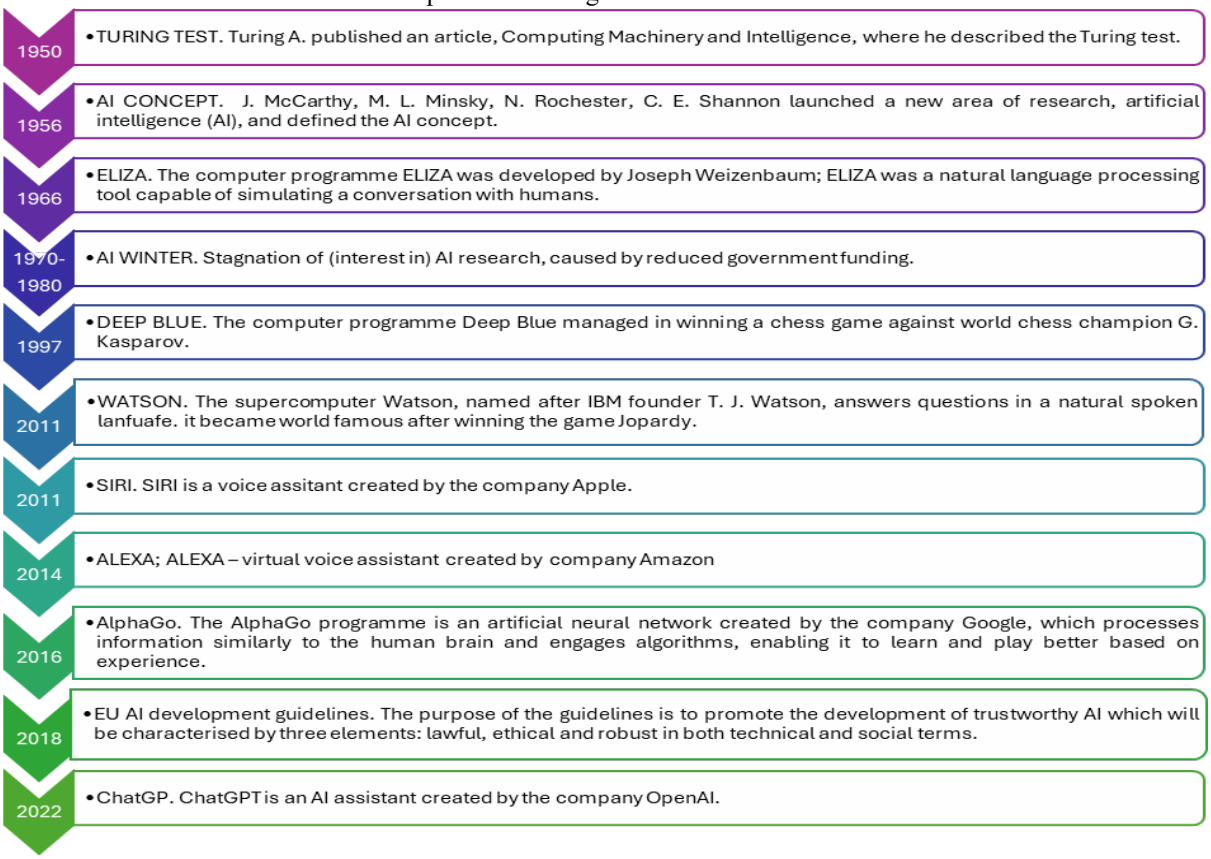

Figure 1. Historical evolution of artificial intelligence

Figure 1 shows how AI has undergone various changes over the last decades. From the development of the Turing test to AI research centres. The current state of AI is very dynamic and broad. AI technologies are spreading rapidly and are being used in a wide range of fields, with impressive results and achievements.

Despite the increased interest in AI, there is still no single approach to defining AI. In scientific and popular literature, AI is defined as a phenomenon, systems, computer science, a set of technological components, information technology, intelligent machines that can simulate human intelligence (see Table 1).

Table 1. AI concept

Source	Definition
EU Council and European Council	AI is the use of digital technologies to create systems that can perform tasks that normally require human intelligence.
OECD	AI is a machine-based system that can provide predictions, recommendations or solutions for a set of human-defined goals that affect real or virtual environments.
Standard ISO/IEC 22989:2022	AI is a technical and scientific field devoted to the engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives.
Lithuanian State Data Agency	AI means systems that use *text* mining, *computer* vision, *speech* recognition, speech recognition, natural language *generation,* machine *learning* and *deep* learning technologies. These systems collect and/or use data to predict, decide or recommend, with a certain degree of autonomy, the best course of action to achieve specific objectives.
Ministry of Economy and Innovation. Lithuanian Artificial Intelligence Strategy. A Vision of the Future (2019)	AI refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems), or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones, or Internet of Things applications).
IBM	AI is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities.
Mokslo Lietuva. Interview with Krilavičius T. (2020)	AI are systems that demonstrate smart behaviour. It is a branch of computer science that focuses on building machines that can simulate routine, non-creative behaviour.
Getchell, K. M., Stephen Carradini, S., Cardon, P. W., Fleischmann, C., Ma, H., Aritz, J., Stapp, J. (2022)	AI is a broad term that is usually used as a catch-all for technologies such as machine learning, deep learning, natural language processing and computer vision.
Truong, Y., & Papagiannidis, S. (2022)	AI is a set of technologies that draw inspiration from human intelligence to perform tasks normally associated with the human mind. AI often includes the following basic principles: (1) a set of algorithms that (2) learns from data (3) to perform a specific task (called narrow AI) or a more complex task that requires little or no human supervision (called general AI).
Vockea, C., Carmen Constantinescua,C., Popescub, D. (2019)	Human-made systems that operate in the physical or digital world with a goal in mind, by perceiving the environment, analysing the collected structured or unstructured data, and using the knowledge derived from this data to decide what action is best to take (within pre-selected parameters) to achieve the desired goal.

Source: Compiled by the authors based on the sources listed in the table

AI has become an interdisciplinary field of science, and its use in business has revealed new aspects, new research trends and potential challenges. Qin, Y., Xu, Z., Wang, X., Skare, M. (2021), based on bibliometric analysis of literature (2,211 documents (studies) from 1,096 sources), structured the research related to AI and economic development and the main research areas between 1986 and 2020 and observed that the number of publications related to AI and economic development increased exponentially during this period, and that the majority of the research linked to AI focused on smart decision making, social governance, labour and capital efficiency, and Industry 4.0 and innovation.

Vocke, C., Constantinescu, C., & Popescu, D. (2019), analysing the AI development, innovations and impacts on business organisation forms and employee competences in EU countries, argue that businesses seeking goal-oriented solutions will need to choose AI systems that require modern AI technologies and employees with new competences. AI development will need to be people-centred, knowledge-intensive, with the aim of boosting productivity and innovation.

Canhoto, A. I. & Clear, F. (2020), in a comprehensive review of scientific articles, pointed out that companies implementing AI and machine learning (ML) will need to consider the elements of AI: input data, the ML algorithm and the output decision resulting from the ML processing, and will need to be able to identify, manage the process of creating (or destroying) the value of both AI and ML.

Mikalef, P., Gupta, M. (2021) in a survey study and expert data assessment of US companies identified the necessary organisational resources that will enable companies to develop AI capabilities and align company performance. According to these authors, companies need to have the resources in place to implement AI. Tangible resources include data, technology and core resources, human resources include competences and skills

of employees (i.e. technical and business skills), and intangible resources, which are crucial, include inter-departmental coordination, capacity for organisational change and risk-taking.

According to Enholm, I., M., Papagiannidis, E., Mikalef, P., Krogstie, J. (2021), it is essential to identify and assess the ability of organisations to use AI technologies in their organisations' activities and to clarify the drivers of the AI value creation and the specifics of the AI value creation process. The drivers of AI adoption include technological, organisational and environmental resources and conditions. In this context, organisations can better assess their ability to successfully apply AI and make better decisions at the value creation stages of the organisation. Only by knowing the potential impact of AI deployment on the value creation process can organisations reduce the risks and costs of AI deployment.

Nils Grashof , Alexander Kopka (2022) firstly emphasise the link between application-specific AI knowledge and the emergence of radical innovation, and secondly, the differences in the adoption of AI in SMEs and large enterprises. They argue that application-specific AI knowledge increases the likelihood of radical innovation. SMEs have an advantage in using AI technologies to create radical innovations. SMEs should focus on AI technologies that allow them to take advantage of innovative technological opportunities that cannot be accommodated in a formalised R&D process in a large company.

Michael Grebe, M., Franke, M. R., Heinzl, A. (2023), analysing the results of a survey of institutions/companies in 28 countries (Asia, Europe and USA) operating in the healthcare, insurance, industrial (including automotive), technology and telecommunications and public sectors, identified the determinants of AI value and formulated recommendations to extend and enhance the value of AI projects. According to the authors, the value and effectiveness of AI comes from setting clear objectives and impact, redesigning business processes to incorporate AI tools, accessibility of data and use of innovative technologies, application of flexible working methods, and the use of AI innovations to improve the organisation's operating model. To expand the use of AI, they recommend identifying opportunities for AI in business, fostering the interaction between people and technology and creating a data-driven organisation, and including a mechanism to monitor the use of AI in business.

Using Data Envelopment Analysis (DEA) and regression analysis, Shuai Wang, Xin Huang, Mengyue Xia, Xing Shi (2024) have found that the positive effects of AI adoption are primarily observed in Chinese state-owned enterprises, traditional manufacturing industries and cities.

AI is transforming the way businesses operate. Increasingly, AI technologies demonstrating intelligent behaviour are being used in marketing, logistics, education and other areas (Table 2).

Table 2. Contributions to AI analysis

Authors	Aims of the study, methods used	Conclusions
Batuchina, A., Baziukė, D., Melnikova, J., Šmitienė, G., Šakytė-Statnickė, G. (2022)	*The aim* is to describe and systematise contemporary AI-based educational technologies and to identify their advantages and disadvantages in creating personalised teaching/learning environments. The method *used* was the analysis of scientific literature.	Intelligent learning platforms create a personalised environment for the learner that is focused on the needs of different learners. It proposes to involve more teachers in the development of digital educational tools and to increase the focus on developing teachers' capacity to use AI.
Getchell, K. M., Carradini, S., Cardon, P.W., Fleischmann, C., Ma, H., Aritz, J., Stapp, S. (2022)	*The aim* is to contribute to the integration of AI into business communication and the development of an AI training strategy. *The method* is analysis of scientific literature.	AI is increasingly being incorporated into business communication, and its use is having an impact on communication in the work environment. Understanding the benefits and risks of AI technologies is crucial to the ethical use of these technologies. The areas of AI research in the field of business communication are as wide and varied as the purposes for which developers and researchers use AI technologies. This research can build on work in other fields and open questions, and the authors propose research on the themes of AI deployment, lexicography and grammar, collaboration, design, trust, bias, governance issues, tool evaluation and demographics. It also provides guidance on how to introduce and apply AI in business communication training.

Authors	Aims of the study, methods used	Conclusions
Isensee, C., Kai-Michael Griese, K. M., Teuteberg, F. (2022)	*The aim* is to assess the link between corporate culture and the use of AI for sustainable organisational development. *The method* is bibliometric analysis of literature.	Corporate culture (attitudes, beliefs, values, behaviours, cooperation, ethics, internal capabilities and strategic orientation) is an important indicator influencing the use of AI for corporate sustainability. A reciprocal relationship has been established between a sustainability-oriented corporate culture and the use of AI for sustainable enterprise development.
Peng Liang, P., Sun, X.,Qi, L. (2023)	*The aim* is to assess the impact of industrial robotics on green innovation. *The method* is correlation analysis.	The use of industrial robots is important for green innovation and promotes the development and quality of green technologies. Industrial robots increase the efficiency and optimisation of production and the level of environmental management. Industrial robotics has an important role to play in fostering green innovation in companies with high labour demand, intense market competition, more polluting production and, consequently, more environmental pollution.
Zheng at all (2023)	*The aim* is to introduce Tencent HD Map AI, an automatic labelling and annotation system for high-resolution maps for automated driving.	With Tencent HD Map AI, HD maps provide faster and more accurate information about the traffic situation in large cities (Shanghai, Beijing, etc.) and high-density areas. It is one of the largest of its kind, serving around 1,000 customers and generating around 30,000 km of HD map data per day. The modular nature of the system allows for quick incorporation of updates.
Jovic, M., Mnasri S. (2024)	*The aim* is to evaluate the ability of ChatGPT 3.5, Llama 2, Bing Chat and Bard to generate negative and persuasive emails and to make recommendations for improvement.	Llama 2.0 has the highest consistency across email types, scoring 48.9 out of 60, followed by Bing Chat at 47.8, ChatGPT 3.5 at 46.7 and Bard at 45.2. AI can help in business communication, but it cannot replace the human being, as AI-generated messages lack clarity of thought and the emotional intelligence that is essential for effective collaboration.

Source: Compiled by the authors based on the sources listed in the table

III.USE OF ARTIFICIAL INTELLIGENCE IN BALTIC ENTERPRISES

Using AI in enterprises

In 2023, 8.8% of EU-27 enterprises with 10 or more employees and self-employed persons was using at least one AI technology. The percentage of companies using AI in any of the Baltic States was below the EU-27 level. In 2023, Estonia had the highest percentage of businesses using AI (5.2%), accounting for 59.1% of the EU-27. It also had the fastest growth rate in the share of enterprises (85.71%), which was 5.43 times higher than in the EU-27. Lithuania has the lowest growth rate in the share of enterprises using AI as a percentage of total enterprises compared to the other Baltic States and the EU-27, but the share of enterprises using AI in 2023 remained higher than in Latvia in 2021, at 4.9%.

The use of AI varies among companies of different sizes. The highest use of AI in Lithuania, Latvia, Estonia and the EU-27 was in large companies. This difference between firms of different sizes could be due to the complexity of implementing AI technologies in the firm, economies of scale, or the costs associated with AI investments (Figure 2).

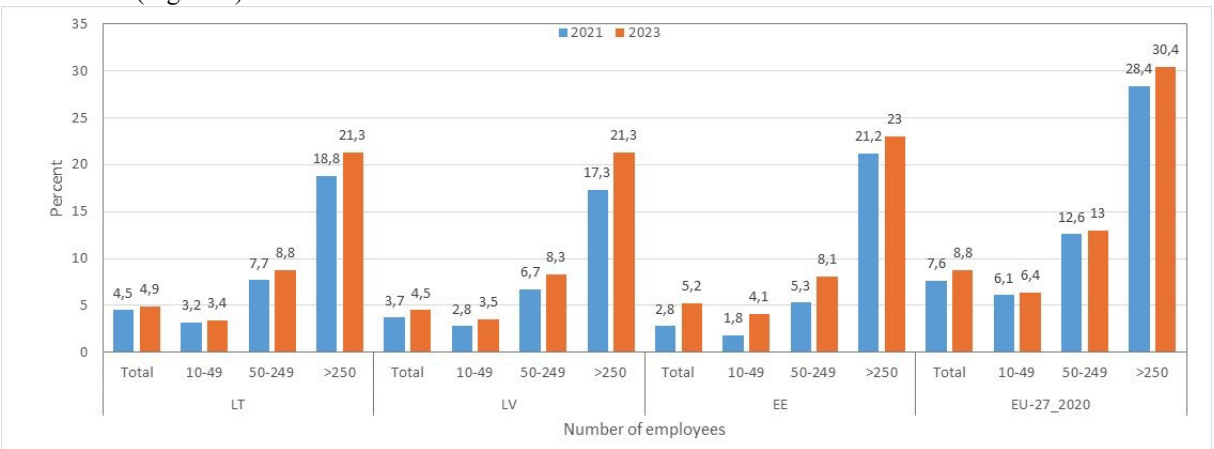

Figure 2. Enterprises using AI technologies by size class, %

Source: compiled by the authors according to the data of the Eurostat data

In 2023, the percentage of large enterprises in Lithuania and Latvia using AI was the same at 21.3%. Estonia had the highest value for this group of companies (23%), accounting for 75.66% of the EU-27. Between 2021 and 2023, the rate of change in the use of AI in medium-sized and large enterprises in Lithuania, Latvia and Estonia exceeded that of the EU-27.

The AI use in the EU-27 grew fastest in large enterprises (7.04%). The growth rate of AI use by Latvian companies in this size group was the fastest among the Baltic States, exceeding the EU-27 by a factor of 3.28 (23.12%). In Lithuania, the use of AI technologies grew fastest in medium-sized enterprises (14.29%) and the use of AI was the highest among the Baltic States (8.8%), accounting for 67.69% of the EU-27. In Latvia and Estonia, the use of AI technologies increased the most in small enterprises (25.0% and 127.78%).

Use of AI by sector

The information and communication sector had the highest share of enterprises using AI in the EU-27 and the Baltic States (Figure 3).

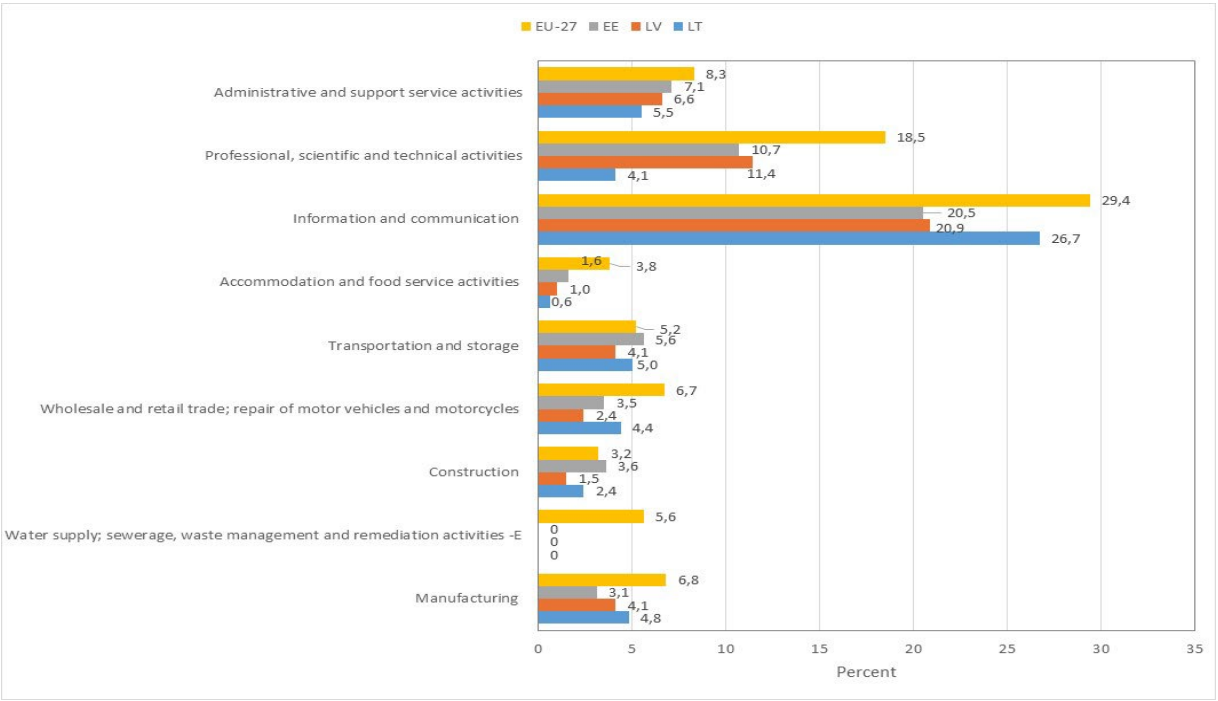

Figure 3. Enterprises using AI technologies by economic activity in 2023, %

Source: compiled by the authors according to the data of the Eurostat data

In Lithuania, the information and communication sector had the highest share of companies using AI in both 2021 and 2023 (22.8% and 26.7%). Although the growth rate of the percentage of Lithuanian enterprises in this sector was the slowest compared to Latvian and Estonian enterprises (17.1%), it exceeded the EU-27 growth rate by 1.35 p.p. In 2023, the share of enterprises using AI was the highest in the Baltic States, accounting for 90.82% of the EU-27 share. The situation in Lithuania was exceptional in the accommodation and food services sector, professional, scientific and technical activities and administrative and support activities, as the percentage of enterprises using AI, unlike in the EU-27 and the other Baltic States, was decreasing at a rate of 84.24%, 43.05% and 12.69% respectively. The share of enterprises in the manufacturing sector using DI in Lithuania has been declining, as in the EU-27, but the rate of decline was much faster in Lithuania and exceeded the EU-27 by a factor of 4.08 (reaching 5.88%).

AI technologies

Companies used a variety of AI technologies: technologies that analyse written language (text mining); technologies that convert spoken language into a computer-readable format (speech recognition); technologies that generate written or spoken language (natural language generation); technologies that recognise objects or people based on images (image recognition, image processing); machine learning (e.g. deep learning) for data analysis; technologies that automate various workflows or help to make decisions (artificial intelligence-based software, robotic automation of processes); technologies that allow machines to physically move around to

observe their environment and make autonomous decisions. The situation in the EU-27 and Lithuania is the same, with AI technologies used mainly to automate various work processes. In 2023, these AI technologies were used by 3% of EU-27 and 2.4% of Lithuanian companies. The second most common use of AI technologies in the EU-27 and Lithuania was for written language analysis (2.9% and 2.3%). The distribution of AI technologies used in enterprises in Latvia and Estonia differs (is not identical) in terms of frequency. In 2023, in Estonia, the main use of AI technologies in companies was for machine learning for data analysis (1.6%) and for image-based object and person recognition (1.5%). Written language analysis AI technologies are most frequently used in Latvian companies (2.3%) (Figure 4).

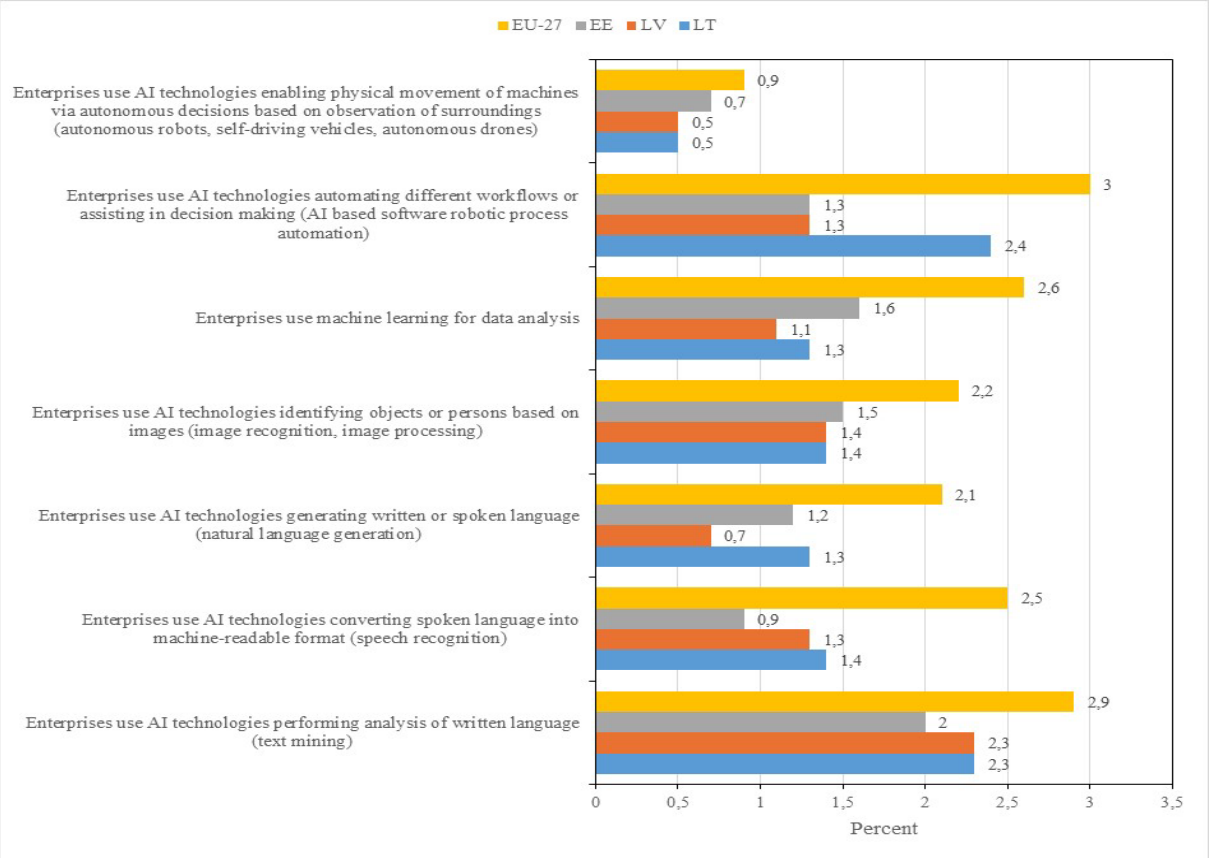

Figure 4. Enterprises using AI technologies by type of AI technology in 2023, %
Source: compiled by the authors according to the data of the Eurostat data

The Baltic States and the EU-27 do not have the same peak growth rates by the type of AI technology. In Lithuania, Latvia and Estonia, the most significant increase is in the replacement of spoken language with computer-readable format (75%, 65.2% and 125% respectively), while in the EU-27 it is in the generation of written or spoken language (61.54%).

The use of AI technologies varies according to the size of companies. In 2023, in the EU-27, Lithuania and Estonia, the situation was similar in large enterprises, with the highest use of AI technologies for automating various work processes (16.4%, 13.1% and 9.1% respectively) and for machine learning for data analysis (14.6%, 8.3% and 10.9% respectively). In Latvian companies, the use of AI technologies for analysing written language was the same as for automating various work processes (8.2% each). Automated solutions based on environmental monitoring to enable the physical movement of machinery were the least used in all Baltic States and the EU-27.

In 2023, medium-sized enterprises in Lithuania and Latvia were mostly using AI technologies for written language analysis (4.9% and 3% respectively), while in Estonia (as in the EU-27), AI technologies for image-based recognition of objects or people were the most common (3%).

In small enterprises in 2023, AI technologies for written language analysis were the most commonly used in all Baltic States, as in the EU-27. In Lithuania, unlike Latvian and Estonian companies, the use of AI technologies for automation of various work processes was not less active (1.6%), which was in line with the EU-27.

Use of AI technologies by sector

The types of AI technologies used varied across economic activities. In the ICT sector, the share of enterprises using AI was the highest in both the EU-27 and the Baltic States, and in Lithuania an exceptionally high share of enterprises used AI technologies to automate various work processes (17.5%). In Latvia and Estonia, the most commonly used AI technologies were for written language analysis. Across the Baltic States, as in the EU-27, the use of AI technologies for machine learning in data analysis was widespread (**Table 3).**

Table 3. ICT sector enterprises using AI technologies by AI technology type in 2023

Enterprises use at least one of the AI technologies	Lithuania	Latvia	Estonia	EU-27
Performing analysis of written language (text mining)	14.8	10.7	13.6	14.2
Converting spoken language into machine-readable format (speech recognition)	5.5	4.9	7.0	10.6
Generating written or spoken language (natural language generation)	9.9	4.8	11.2	11.1
Identifying objects or persons based on images (image recognition, image processing)	8.7	6.5	7.5	9.8
Machine learning (e.g. deep learning) for data analysis	17.3	8.2	10.5	16.2
Automating different workflows or assisting in decision making (AI based software robotic process automation)	17.5	5.0	4.7	12.2
Enabling physical movement of machines via autonomous decisions based on observation of surroundings (autonomous robots, self-driving vehicles, autonomous drones)	3.0	1.1	1.2	2.9

Source: compiled by the authors according to the data of the Eurostat data

Aims for using AI technologies

Businesses use AI for different purposes: marketing or sales; production processes; organisation of business administration processes; enterprise management; logistics; IT security; research and experimental development (R&D) or innovation activities; accounting, control and financial management. The aims for which AI technologies were used in 2023 varied according to the business sector ***(Table 4)****.*

Table 4. Aims with the highest use of AI technologies by business sector and country in 2023, % of total

Economic activity	Lithuania	Latvia	Estonia	EU-27
Manufacturing	For production processes (38.6 %)	For production processes (39.0 %)	For production processes (37.6 %)	For production processes (38.2 %)
Electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities	For ICT security (58.3%)	For accounting, controlling or finance management (51.1%)	For production processes (51.4 %)	For ICT security (37.6%)
Construction	For accounting, controlling or finance management (40.7 %)	For accounting, controlling or finance management (90.5 %)	For ICT security (31.1%)	For accounting, controlling or finance management (32.1%)
Wholesale and retail trade; repair of motor vehicles and motorcycles	For marketing or sales (41.0%)	For marketing or sales (35.8%)	For accounting, controlling or finance management (46.9 %)	For marketing or sales (41.8%)
Transportation and storage	For research and development (R&D) or innovation activity (40.7 %)	For marketing or sales (33.3%)	For logistics (38.7%)	For ICT security (28.6%)

Economic activity	Lithuania	Latvia	Estonia	EU-27
Information and communication	For ICT security (41.1%)	For marketing or sales (37.3%)	For marketing or sales (60.5 %)	For research and development (R&D) or innovation activity (41.3 %)
Professional, scientific and technical activities	For accounting, controlling or finance management (46.9 %)	For accounting, controlling or finance management (52.2 %)	For production processes (43.2 %)	For accounting, controlling or finance management (33.0 %)
Administrative and support service activities	For marketing or sales (45.5%)	For accounting, controlling or finance management (37.9 %)	For marketing or sales (70.4 %)	For ICT security (28.6%)

Source: compiled by the authors according to the data of the Eurostat data

In the manufacturing industry, AI technologies were mainly used for production processes in both the EU-27 and the Baltic States. In Lithuania, as in the EU-27, AI technologies for IT security were mainly used in the water supply, wastewater treatment, waste management and recovery sectors and remained one of the most important targets for companies in the information and communication sector (41.1%). AI technologies for accounting, control and financial management in Lithuania, Latvia and the EU-27 were mainly used in construction and professional, scientific and technical activities.

Ways of acquiring artificial intelligence

AI technologies are acquired by enterprises in a variety of ways: software or systems are developed by the enterprise's own staff; the enterprise's own staff customises the purchased software; the enterprise's own staff modifies the open-source software or systems; the enterprise purchases off-the-shelf software from other companies; external providers develop or modify the technology for the enterprise. The most common way of acquiring AI technologies in the Baltic States and the EU-27 is through the same process: purchasing off-the-shelf software from other companies. In 2023, AI technologies were acquired in this way by 2.2% of Lithuanian, 2.3% of Latvian, 3.4% of Estonian enterprises and in 2021 by 3.7% of EU-27 enterprises. The second most common way of acquisition in Lithuania, Latvia and the EU-27 was when companies acquired customised AI technology developed or modified for them by other companies (1.8%, 1.3% and 2.7% respectively). The second most common way used in Estonian companies was the adaptation of commercial software by company employees (2.8%). Lithuanian and Latvian companies were the least likely to use this method (1.2% and 0.8% respectively), while Estonian and the EU-27 companies were the least likely to have their employees modify open source applications or systems (1.5% and 1.6% respectively).

The growth rates in the Baltic States in terms of AI acquisition methods were not high. The highest growth rate was observed in Estonia, with a 2% increase in the share of companies purchasing off-the-shelf applications or systems from other companies. The fastest growth rate in Lithuanian companies was 0.5 p.p., the share of companies whose employees adapted the purchased software for their use. In Latvia, only the share of enterprises that acquired AI technologies by modifying open source software for company employees remained the same, while the share of enterprises that acquired them by other means decreased.

There was little variation in the way AI technologies are acquired across company sizes, but the largest overlaps were observed in the group of large enterprises. In 2023, large companies in Lithuania, Latvia and Estonia were the most likely to purchase ready-to-use software from other companies (12.3%, 13.0% and 17.0%). In the EU-27, large companies were also the most frequent users of this method in 2021 (16.8%). Only in Estonia in 2021 were AI applications most often developed by company employees (14.4%). Across the Baltic States and the EU-27, large and medium-sized enterprises were the least likely to have purchased AI technologies for the modification of open source software by company employees.

In 2023, Lithuanian medium-sized enterprises were equally likely to use three types of software acquisition: software developed by employees, ready-to-use software purchased from other companies, or customised software developed by other companies (3.7%). Latvian and Estonian companies were the most frequent purchasers of off-the-shelf software from other companies (4.1% and 4.8%).

In 2023, Baltic and in 2021 EU-27 small enterprises mostly purchased ready-to-use software from other companies. Lithuanian and Latvian companies were the least likely to start using software purchased and

customised by company employees, while in Estonia and the EU-27 companies were the least likely to modify open source software.

Reasons for not embracing artificial intelligence technologies by enterprises

While AI is increasingly becoming a driver of business progress, less than 10% of EU companies use at least one artificial intelligence technology. Therefore, when analysing the potential of these technologies, it is useful to look at the reasons that are holding them back. According to Eurostat, the eight most important reasons are: *(1) Excessive costs, (2) Lack of appropriate expertise in companies, (3) Incompatibility with existing equipment, software or systems, (4) Difficulties in the availability or quality of the data required, (5) Concerns about data protection and privacy breaches, (6) Uncertainty of legal implications, (7) Ethical reasons, (8) AI technologies are not useful for companies.*

There are a number of companies in both the Baltic States and the EU-27 that do not use AI but are considering it. When analysing the reasons for holding back the adoption of AI, the reasons cited by Lithuanian companies were more often the same as those cited by Latvian companies, and by Estonian companies than those mentioned by the EU-27. Lithuanian and Latvian companies cited high costs as the main reason holding back AI deployment. In 2021-2023, the share of such enterprises in the total number of enterprises was 5.4% and 5.5% in Lithuania, and 3.5% and 3.4% in Latvia respectively (Figure 5).

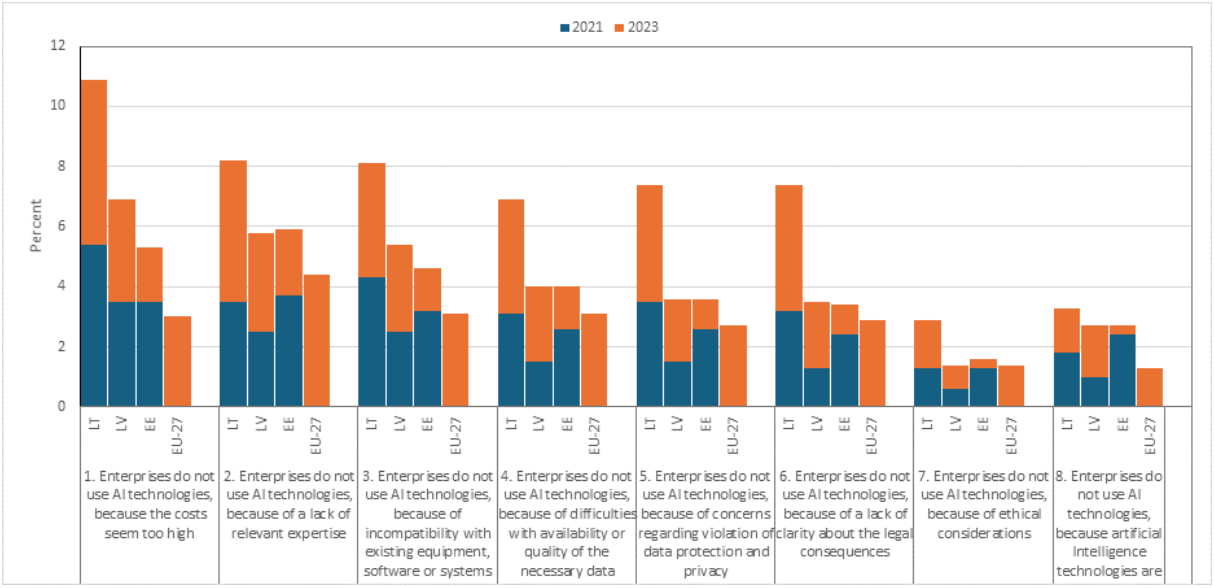

Figure 5. Reasons holding back the adoption of AI in the Baltic States

Source: compiled by the authors according to the data of the Eurostat data

Estonian companies identified a lack of the necessary competences in their companies as the main reason (3.7% and 2.2% respectively). The opinion of EU-27 enterprises coincided with that of Estonia, and in 2021 the share of enterprises with this view was 4.4%. In 2023, the second most frequently cited reason in Lithuania and Latvia was the lack of appropriate competences in companies (4.7% and 3.3% respectively), while in Estonia it was too high costs (1.8%), while the EU-27 countries indicated two reasons: incompatibility with equipment owned by them and difficulties with access to the required data and quality (3.1% each). Ethical reasons and AI technologies not being useful in enterprises seemed to be the least important for companies in the Baltic States and the EU-27 in 2021-2023.

The fact that Estonia has made a significant leap forward in AI deployment is also shown by the fact that in Lithuania and Latvia in 2023 an increasing proportion of companies interpreted almost every reason as a problem. In Estonia, on the contrary, the share of such enterprises decreased (in all groups of enterprises). The percentage of those who believed that companies lack the right skills increased by 1.2 p.p. in Lithuania, 0.8 p.p. in Latvia and 1.5 p.p. in Estonia. The number of respondents who said they had difficulties with the availability or quality of the data they needed increased by 0.7 p.p. in Lithuania, by 1.0 p.p. in Latvia and by 1.2 p.p. in Estonia. The number of people concerned about data protection and privacy breaches increased by 0.4 p.p. in Lithuania, by 0.6 p.p. in Latvia and by 1.6 p.p. in Estonia. The impression is that Estonian companies have already looked into these reasons and most companies have found a solution.

Looking at the distribution of opinions in the context of the size of enterprises, Baltic enterprises of all sizes (with the exception of Estonian small enterprises in 2021) ranked excessive costs as the most important or

second most important reason for holding back AI deployment, while small enterprises in the EU-27 ranked it as the second most important reason (along with the other three), while medium-sized enterprises ranked it as the fifth most important reason, and large enterprises ranked it as the sixth reason.

In 2023, the most important reason for hindering the use of AI changed in all Baltic States in the group of large enterprises. In Lithuania and Latvia, it was the lack of appropriate competences in the company (13.6% and 10.1% respectively), while in Estonia it was the lack of compatibility of existing equipment and software with AI technologies (5.5%). Latvia saw the highest growth rates: a 6.8-fold increase in the proportion of those saying that ethical issues were a constraint to the use of AI, and an almost 3-fold increase in the proportion of those saying that the use of AI was hampered by difficulties in the availability and quality of the required data.

In 2023, Lithuanian medium-sized companies cited too high costs as the main reason for not using AI (5.4%), which was by 1.5% more than in the EU-27. Latvia, Estonia and the EU-27 - lack of appropriate competences in companies (5.7%, 3.9% and 6.6% respectively). The highest growth rate was in Latvia, with a 1.1% increase in the proportion of those concerned about the uncertainty of the legal effects, and in Lithuania, with a 0.5% increase in the proportion of those concerned about ethical considerations.

For small enterprises, the main obstacle in Lithuania and Latvia was overly high costs. In 2021-2023, it was cited by Lithuanian enterprises (4.8% and 5.3% respectively) and Latvian enterprises (3.1% and 3.0% respectively). In Estonia and the EU-27, the main reason was the lack of appropriate competences in the company.

IV. CONCLUSION

Over the last decades, AI has undergone various changes, from the development of the Turing test to artificial intelligence research centres. AI technologies are spreading rapidly and are being used in a wide range of fields, with impressive results and achievements.

In 2021-2023, the share of Baltic enterprises as a percentage of all enterprises with 10 or more employees, using at least one AI technology, increased but failed to reach the EU-27 level in any of the countries. Although the growth rate in the use of AI technologies was the lowest in Lithuania, the share of enterprises using AI in 2023 remained higher than in Latvia.

In Lithuania, Latvia and Estonia, the extent of use of AI technologies by enterprise size class was in line with the EU-27, with the majority of use in large enterprises. However, the highest growth rate in the use of AI technologies by enterprise size class did not coincide with that of the EU-27: in Lithuania, the highest growth in the use of AI technologies was observed in medium-sized enterprises, while in Latvia and Estonia it was seen in small enterprises.

According to the economic activity, in 2021 and 2023 the use of AI in the Baltic States, just as in the EU-27 countries, was dominant in the information and communication sector. In all the Baltic States, the growth rate of the percentage of companies using AI technologies in this sector exceeded that of the EU-27. In 2023, the share of Lithuanian enterprises using AI was the highest compared to the other Baltic States, accounting for 90.82% of the EU-27 result.

Although there was a wide variety of AI technologies used in enterprises, the trends in the EU-27 and Lithuania were the same, with AI technologies used mainly to automate various work processes. In Estonia, the main use of AI technologies was in machine learning for data analysis, while in Latvia it was for written language analysis.

The purposes for which AI technologies were used in the Baltic States and in the EU-27 varied depending on the sector of activity. In 2023, only in the manufacturing industry AI technologies in both the EU-27 and the Baltics were mainly used for the same purpose or automation of production processes.

Companies in both the Baltic States and the EU-27 tended to buy off-the-shelf AI applications and systems from other companies. The ways most rarely used by the countries to acquire AI did not coincide. Lithuanian and Latvian enterprises were the least likely to purchase AI where their employees would customise the acquired applications, while Estonian and EU-27 enterprises were the least likely to purchase AI with their employees modifying open source applications.

When analysing the reasons that hinder AI deployment, it is again noticeable that the opinion of Lithuanian enterprises was more often in line with Latvia, and of Estonia with the EU-27. Lithuanian and Latvian enterprises identified too high costs as the main reason holding back the use of AI, while Estonia and the EU-27 countries cited the lack of the right competences in the company. Estonia's rapid progress in AI deployment is also reflected in the fact that in 2023 a decreasing share of enterprises (across all enterprise groups) interpreted the reasons for not deploying AI as a problem, while the share of such enterprises increased

in Lithuania and Latvia. As EU funding for AI development and deployment is increasing, there is a growing perception among EU-27 companies that AI deployment is more hampered by the lack of the right competences and difficulties in access to, and the quality of the required data than by the high cost of deployment.

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