

# The Interdependence of Cloud Computing and Artificial Intelligence in the Digitalisation of SMEs in the European Union

Adam Péntek<sup>1</sup>, Szilvia Botos<sup>2</sup>, Tamás Kovács<sup>3</sup>

## INFO

Received:08/11/2025

Accepted:01/12/2025

Available on-line: 02/02/2026

Responsible Editor: László Várallyai

## Keywords:

Cloud computing, SME,  
Artificial Intelligence, Eurostat.

JEL: O33, L26, M15

## ABSTRACT

Digitalisation is the most significant shaping factor of today's economy, creating new opportunities and challenges, especially for small and medium-sized enterprises (SMEs). This study aims to explore the extent and structural differences in how SMEs in the European Union use cloud computing and artificial intelligence (AI) services, and how these two technologies are interconnected in terms of digital maturity and competitiveness.

The research is based on Eurostat data from 2018 to 2024, applying a descriptive statistical approach. According to the results, cloud computing is the foundation for the digitalisation of SMEs: in 2024, 41.7% of small companies, 59% of medium-sized companies, and 77.6% of large companies utilised cloud services. However, the use of AI is more limited, with 11.2% of small companies, 21% of medium-sized companies, and 41.2% of large companies having adopted AI-based solutions. The data indicate a strong complementary relationship between the two technologies: cloud infrastructure provides the data and computational conditions necessary for AI to operate. At the same time, AI enhances the business value of cloud use by evaluating and automating data.

At the sectoral level, the information and communication technology (ICT) sector, along with other knowledge-intensive services, is at the forefront of both technologies. At the same time, the manufacturing and construction industries continue to lag significantly. At the regional level, the high adoption rates in Northern and Western European countries stand in stark contrast to those in Eastern and Southern Europe, where technological infrastructure, digital competencies, and investment opportunities are more limited.

The study concludes that cloud and AI technologies are not only complementary but also form the basis of digital development for SMEs. The success of digitalisation is also a result of organisational and cultural adaptation. The long-term competitiveness of SMEs depends on their ability to integrate these technologies into their operations with a strategic approach and conscious innovation.

## 1. Introduction

Digitalisation is the driving force of today's economy, fundamentally transforming the operating models, competitiveness, and market adaptability of companies. Small and medium-sized enterprises (SMEs) play a pivotal role in the European Union's digital economy strategy, as they account for a substantial portion of employment and economic growth in Europe. At the same time, businesses in the digital transition often face a lack of resources, technological backwardness, and competence

---

Adam Péntek<sup>1</sup>

University of Debrecen, Faculty of Economics and Business Administration, Institute of Methodology and Business Digitalisation, Hungary  
pentek.adam@econ.unidebb.hu

<sup>2</sup> Szilvia Botos

University of Debrecen, Faculty of Economics and Business Administration, Institute of Methodology and Business Digitalisation, Hungary  
botos.szilvia@econ.unidebb.hu

<sup>3</sup> Tamas Kovacs<sup>3</sup>

University of Debrecen, Faculty of Economics and Business Administration, Institute of Methodology and Business Digitalisation, Hungary  
kovacs.tamas@econ.unidebb.hu

barriers, which hinder the widespread adoption of more advanced technologies, such as cloud services or artificial intelligence.

The two key technological directions that determine the level of digitalisation development are the use of cloud services and the utilisation of artificial intelligence (AI) services. The use of cloud-based services enables companies to store data flexibly, support remote work, reduce IT costs, and scale their digital infrastructure. Its use creates the opportunity for SMEs to access IT capacities that were previously only available to large companies.

The use of artificial intelligence represents a new level of digitalisation. The introduction of AI technologies increases operational efficiency, creating opportunities to strengthen data-driven decision-making, automated process control, and innovation activities. Artificial intelligence in the SME sector typically appears in the fields of marketing, customer relationship management, financial administration, and IT security, whereas machine learning, image processing, and predictive analytics are primarily strategic tools used by large companies.

The two technologies are closely intertwined and even complement each other. Cloud systems provide the data and computing infrastructure on which AI algorithms are built, so the uptake of AI is closely linked to the use of cloud computing. In countries and sectors with high cloud usage, the level of AI adoption is also much higher. In contrast, in the Eastern and Southern European regions, where access to cloud infrastructure is less common, AI adoption is also less common. This pattern highlights that the level of digitalisation is not only a function of technological factors, but also of structural and cultural factors.

Cloud services and artificial intelligence are interconnected elements of the development of the digital economy. For SMEs, these technologies are not only a competitive factor but also a prerequisite for long-term sustainability and innovation. This article illustrates the extent to which small and medium-sized enterprises in Europe are utilising these technologies, based on available Eurostat data. What differences can be observed by size, sector, and region? And how to interpret the interdependent role of cloud computing and AI in the process of digitalisation. The study is descriptive, and its aim is not to explore the statistical correlations in depth, but to present the European trends, patterns, and challenges that determine the digital future of SMEs in the European Union. The study also serves as a guide for Hungarian small and medium-sized enterprises to gain a comprehensive understanding of the directions of EU digitalisation processes and to identify their position within these international trends.

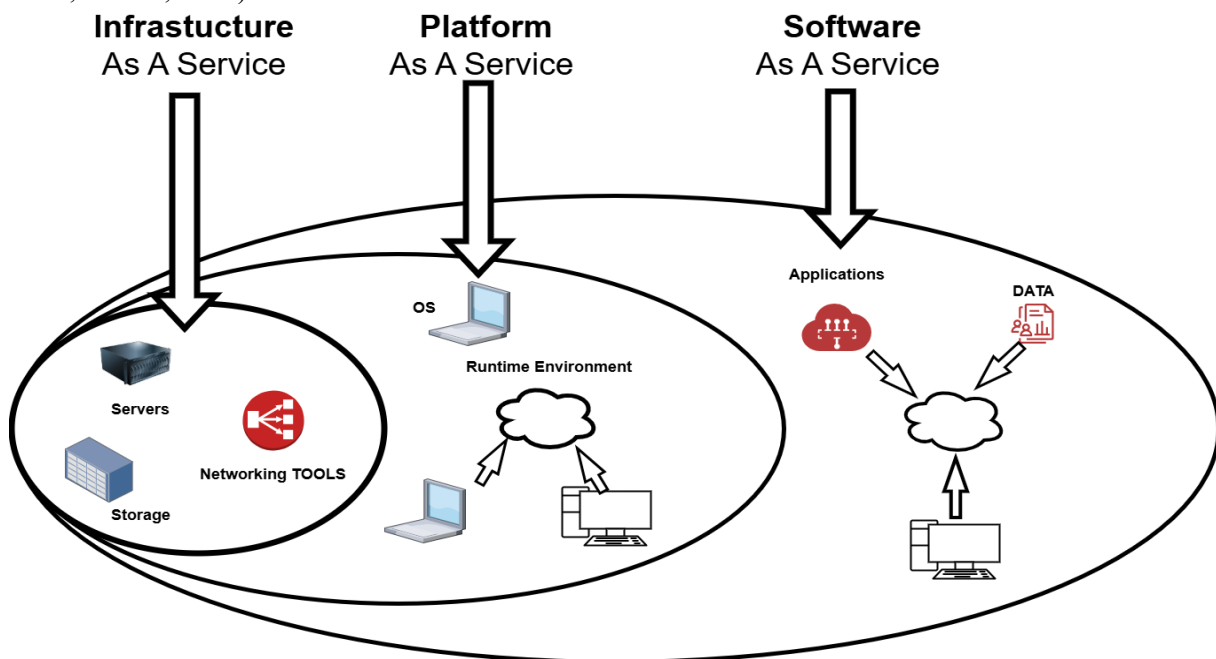
## Literature review

Small and medium-sized enterprises (SMEs) are the basic units of the European economy. They account for more than 99% of businesses in the European Union. They provide about two-thirds of employment and more than half of the value added. (European Investment Fund., 2024). Their role in the economic fabric is crucial not only for job creation but also for innovation, regional cohesion, and social stability. At the same time, SMEs often face structural disadvantages, such as limited capitalisation, a scarcity of human resources, and a lack of expertise and technology to invest in digitalisation. (Brávác & Krebsz, 2021). These factors make it significantly more difficult to integrate more advanced information and communication technologies (ICT), which is key to staying competitive in this globalised, data-driven economic environment. (Harsányi et al., 2022).

The concepts of digital maturity and e-readiness have become a defining element of corporate performance in the last decade. Digital maturity is a composite metric that expresses a company's ability to integrate digital technologies into its operational, customer relationship, and strategic processes (Sándor & Gubán, 2021). Organisations with higher digital maturity are more flexible in responding to market changes, using data more efficiently for decision-making, and are more easily able to develop new business models (Sándor & Gubán, 2021). E-readiness is a closely related but broader concept that encompasses not only technological capabilities but also infrastructure, human resource qualifications, institutional environment, and digital culture (Sándor & Gubán, 2021). In the

case of SMEs, a lower level of e-readiness often limits the possibility of adopting advanced technologies, even if managers recognise their strategic importance (Szabó et al., 2021). According to (González-Varona et al. (2021), the digital development of SMEs can be described as a phased process, one of the phases of which is the adaptation of cloud computing. Cloud technologies are democratizing access to resources, enabling small businesses to leverage scalable computing capacity, remote data access, and collaboration (Al-Sharafi et al., 2023). Cloud computing is therefore not only a technological development, but also a guarantee of digital infrastructure and business flexibility (Lu & Shaharudin, 2024). Several studies have highlighted a strong correlation between the adoption of cloud services and enterprise innovation, cost reduction, and improved information security (Al-Sharafi et al., 2023; Ognjanović et al., 2024; Yousef et al., 2023). For SMEs, the adoption of cloud solutions is significant, as they are often the only means to counteract the technological superiority of large companies (Mousa et al., 2024).

Cloud solutions can take different forms in the way companies operate: IaaS (Infrastructure as a Service) allows flexible and scalable rental of IT infrastructure, such as servers, storage, and network resources, while PaaS (Platform as a Service) provides a development environment that makes it easy to create and operate custom applications without the need for the company to manage the core infrastructure. The top level is SaaS (Software as a Service), which offers ready-made, subscription-based software such as office suites, business management systems, or customer relationship management systems. These service models build upon each other to create flexibility in digital infrastructure, allowing businesses of all sizes to access modern IT resources. (Lu & Shaharudin, 2024; OECD, 2021).



1. Figure Key models for cloud services (IaaS to PaaS to SaaS)

source: (Oluwafemi Clement Adeusi et al., 2024)

According to Segarra-Blasco et al. (2025), the emergence of artificial intelligence (AI) has opened up a new dimension in digitalisation, which offers companies a wide range of opportunities from operational optimisation to strategic decision-making. The role of AI technologies in optimising business operations and driving data-driven decision-making is becoming increasingly important, presenting new opportunities, especially for small and medium-sized enterprises (Lengyel et al., 2025). AI applications are increasingly capable of automating repetitive tasks, predicting market trends more accurately, and supporting personalised customer relationships (Le Dinh et al., 2025). For SMEs, the use of AI primarily serves to increase operational efficiency and maintain competitiveness; however, its adoption is strongly dependent on the technological background, data management skills,

and digital awareness. Businesses that have successfully integrated cloud infrastructure in the past will be able to implement AI solutions more easily, as they already have the necessary data storage, processing, and security conditions (Mkhize et al., 2024). In a rapidly changing global environment, the level of digitalisation and the ability to adapt to new technologies will determine whether SMEs can remain competitive (da Silva et al., 2025). AI and cloud computing play a mutually reinforcing role in this process. Cloud technology provides the necessary infrastructure and data management capacity, while AI enables data interpretation, automated decision-making, and predictive operation. Through the active use of technologies, a higher level of digital maturity can be achieved, allowing the company to proactively respond to market challenges and integrate new technologies into its strategic operations. However, the digitalisation of small and medium-sized enterprises is not only a matter of technological transformation, but also one of organisational and cultural transformation. Without deeper integration of digitalisation, SMEs will face a competitive disadvantage in the long run, as the lack of cloud-based systems and AI technologies limits their ability to make data-driven decisions, tap into innovation potential, and respond rapidly to market changes (Bianchini & Lasheras Sancho, 2025). It follows that the key to future economic development lies in increasing the digital maturity of the SME sector.

## Methodology

The study is based on descriptive secondary data analysis, aimed at examining the level of digitalisation among European SMEs and the application patterns of new technologies, particularly cloud computing and AI. The research focuses on the question of the extent to which and with what structural differences the adaptation of these two technologies appears among SMEs. Additionally, we would like to explore the potential connections between them in terms of digital development. The data source for the study was Eurostat's publicly available harmonised enterprise information and communication technology databases, mainly the 2021-2024 editions of the datasets "Enterprises using cloud computing services" (Eurostat, 2020) (`isoc_cicce_use`) and "Enterprises using AI technologies" (Eurostat, 2025b) (`isoc_eb_ai`; `isoc_eb_ain2`). The databases are produced using a uniform methodology, ensuring comparability between Member States. The data refer to enterprises employing more than 10 people, categorised by size (small, medium-sized, and large enterprises) and economic sector.

For cloud services, the study was based on indicators such as the share of companies using cloud solutions across all businesses and the type of services (e.g., email, data storage, financial software, computing capacity). In the case of AI technologies, the study examined the proportion of companies using AI in at least one target area, with a particular focus on the application purposes (marketing, administration, production, ICT security, research and development) and the types of AI used (e.g., machine learning, natural language processing, image recognition).

The purpose of the analysis is to present patterns, differences, and trends. The methodology focuses on differences in size (SMEs vs. large companies) and regional differences (Northern, Western, Eastern, and Southern Member States). In addition, the analysis aims to present the differences in digitalisation across sectors, revealing which sectors are at the forefront of adopting cloud and AI technologies and in which areas there is a lag. One of the starting points of the methodological approach is that AI and cloud computing are complementary technologies; therefore, examining them jointly helps to interpret digital maturity in the analysis. AI adoption requires an appropriate IT infrastructure and data access, which cloud services can provide. The study therefore evaluates the spread of the two technologies in relation to each other, focusing on the digital development path of SMEs from cloud-based infrastructure to data-driven operations.

The limitations of the analysis include the fact that Eurostat data are self-reported, and not all Member States provide a whole series of data. In addition, the data used are descriptive so that no causal relationships can be established; however, the study is still able to present the current state and direction of digitalisation trends among European SMEs. The strength of the methodology lies in the comparability and representativeness of the data, which enable the analysis of macro-level patterns in the EU digital economy, broken down by company size and sector.

## 4. Results and analysis

### 4.1. Take-up of cloud services among SMEs

The use of cloud computing has become one of the most dynamically growing digital technology trends in the European Union in recent years. According to Eurostat data, in 2018, only 26% of EU businesses used cloud solutions, rising to 41% in 2021 and 45.2% in 2023. This represents a nearly 20 percentage point increase over five years, indicating the rapid expansion of digital infrastructures and the acceleration of technological adaptation. The trend reflects the fact that cloud-based solutions are not only for IT development but have become the fundamental infrastructural pillars of corporate operations, data management, and collaboration. At the same time, the data also show that the pace of growth has slowed down over the last two years, suggesting that the market is gradually saturating and further expansion depends mainly on the level of digitalisation of small and medium-sized enterprises.

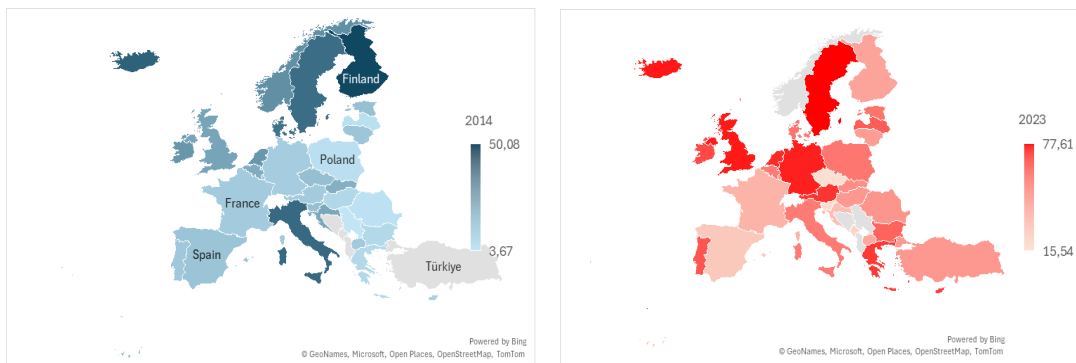
1. Table Change in the share of enterprises using cloud computing services in the EU Member States by sector, 2018-2023 (percentage points)

	MAN	CON	WRT	TS	AFS	ICT	PST	ASS
Belgium	N.D.	12,9%	11,7%	N.D.	N.D.	N.D.	71,4%	1,4%
Bulgaria	6,3%	6,9%	8,4%	11,1%	10,0%	15,1%	35,9%	5,8%
Czechia	22,3%	22,0%	23,4%	14,3%	17,2%	24,0%	62,4%	9,0%
Denmark	14,3%	10,0%	16,4%	16,0%	8,6%	9,8%	80,4%	12,8%
Germany	23,7%	21,3%	26,4%	19,3%	22,2%	25,5%	64,7%	21,6%
Estonia	23,9%	26,3%	27,0%	27,3%	13,2%	18,6%	82,9%	6,8%
Ireland	23,0%	12,7%	19,9%	22,1%	11,2%	6,6%	82,2%	10,7%
Greece	N.D.	17,2%	12,0%	10,3%	4,3%	N.D.	50,0%	12,5%
Spain	9,6%	4,7%	7,7%	5,6%	1,6%	10,4%	44,0%	10,8%
France	6,3%	6,8%	7,8%	1,8%	4,8%	10,0%	45,2%	7,1%
Croatia	17,9%	12,0%	18,5%	6,9%	7,6%	12,0%	59,3%	N.D.
Italy	40,2%	43,6%	37,5%	42,9%	35,0%	25,0%	80,6%	37,3%
Cyprus	30,0%	27,6%	31,0%	29,7%	16,1%	31,2%	64,2%	23,6%
Latvia	20,8%	16,4%	20,2%	20,9%	14,0%	22,5%	62,6%	23,7%
Lithuania	17,8%	17,7%	15,4%	15,2%	17,6%	21,3%	42,5%	5,7%
Luxembourg	5,1%	15,4%	15,8%	11,3%	-3,5%	6,3%	57,4%	6,2%
Hungary	28,9%	24,1%	27,7%	25,9%	21,5%	26,9%	61,3%	26,4%
Malta	41,1%	25,1%	33,6%	23,1%	29,6%	10,1%	79,9%	28,5%
Netherlands	20,0%	13,6%	18,9%	12,2%	14,5%	10,4%	82,6%	11,1%
Austria	24,3%	22,3%	21,3%	14,2%	18,9%	N.D.	65,9%	15,9%
Poland	47,8%	39,1%	45,0%	34,4%	45,3%	36,4%	70,6%	39,0%
Portugal	13,9%	7,9%	8,0%	N.D.	12,9%	13,0%	N.D.	14,7%
Romania	8,9%	4,5%	8,8%	5,9%	-1,8%	20,7%	34,5%	7,3%
Slovenia	15,2%	7,3%	19,7%	23,2%	6,0%	-3,5%	63,8%	21,3%
Slovakia	13,6%	16,7%	12,3%	10,3%	5,7%	9,6%	41,0%	23,6%
Finland	17,1%	16,6%	5,5%	13,9%	N.D.	8,5%	91,3%	23,7%
Sweden	14,0%	20,9%	13,7%	14,7%	18,4%	8,2%	90,3%	-2,9%

source: own creation based on (Eurostat, 2025b)

According to Eurostat (2025), the use of cloud services by small and medium-sized enterprises (SMEs) increased between 2018 and 2023 in all European Union Member States. Still, the pace and level of growth varied significantly. While the share of cloud use in the EU-27 averaged around 30% in 2018 and was close to 50% in 2023, the increase was more moderate in Hungary, with only 22% of SMEs using some form of cloud computing service in 2018 and 35% in 2023. This growth, although positive, is slower than the EU average ( $\approx +17$  percentage points) and suggests that the digital convergence of the Hungarian SME sector has only partially followed European trends. Hungary ranks around 20th to 22nd out of 27 member states in terms of cloud computing use, placing the country among those with lower digital maturity.

At the sectoral level, the differences are even more pronounced. In Hungary, 55% of SMEs in the ICT sector already used cloud services in 2023, which is close to the EU average ( $\approx 60$ – $65\%$ ), but there is still a significant lag in the manufacturing industry (32%), construction (28%), and trade (33%). In countries with developed digital infrastructure, these ratios are typically around 50-60%, meaning the Hungarian industrial and service sectors are about 15-20 percentage points below the EU average. In terms of the nature of growth between 2018 and 2023, development in Hungary is steady, but not staggering: in most sectors, an increase of 10–13 percentage points can be observed, whereas in the EU, this growth ranges between 15% and 25%. This suggests that Hungarian SMEs are more followers than pioneers in the adoption of cloud-based technologies, and that the engine of digitalisation is primarily located in the ICT and service sectors. The data highlight that the cloud usage of Hungarian SMEs is positive, showing moderate growth, and structural differences persist compared to the more developed regions of the EU. The pace of adaptation can be largely attributed to the limited level of infrastructure, human competencies, and innovation investments.



2. Figure Share of businesses using cloud services in Europe, 2018-2023

Source: own edit (based on (Eurostat, 2025a))

Regional differences are also significant between the Member States of the European Union. While enterprise adoption of cloud services is already over 70% in Northern and Western European countries (e.g., in Finland, Sweden, and Denmark), in Eastern and Southern European regions such as Hungary, Bulgaria, and Greece, this share remains around 30-40%. Nevertheless, data from 2018 to 2023 clearly indicate that progress has been made in all Member States, showing the gradual spread of digitalisation and cloud solutions. However, the differences can still be attributed to variations in infrastructure development, corporate willingness to innovate, and digital competencies.

We can conclude that the spread of cloud-based services is one of the most significant drivers of the digital economy; however, improving the digital readiness of SMEs is crucial to sustain further growth. The key to future development lies in strengthening cloud-related knowledge, security infrastructure, and data management competencies, which are also prerequisites for integrating artificial intelligence and other advanced technologies.

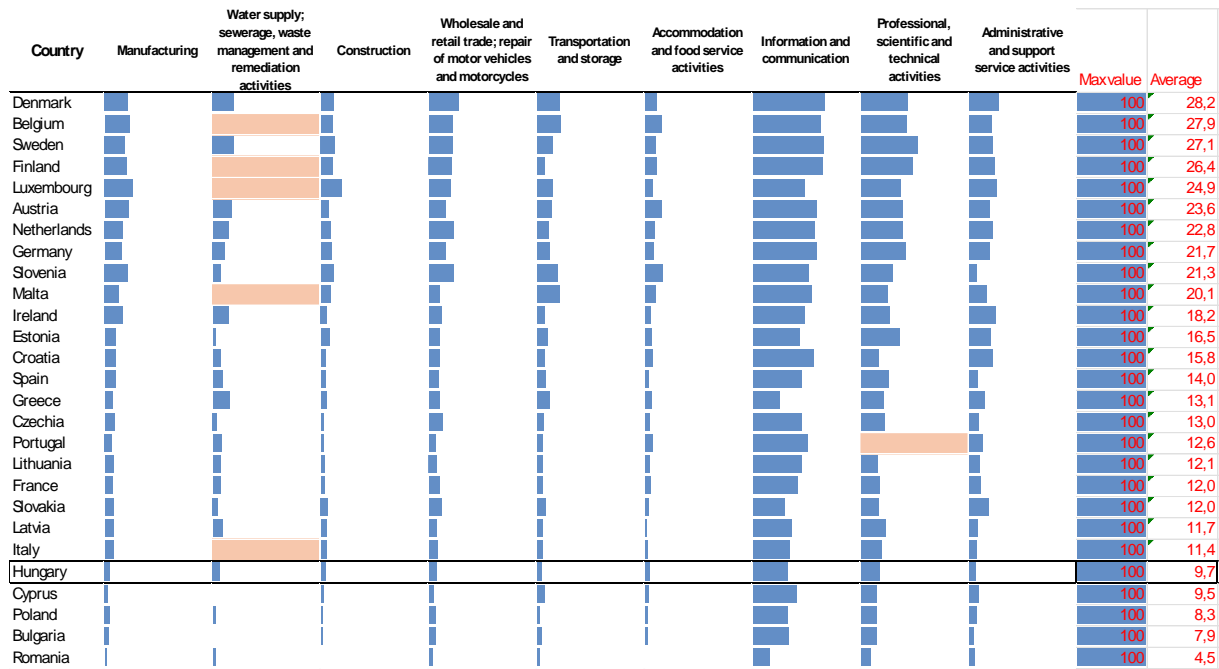
## 4.2. Uptake of AI technologies among SMEs

Artificial intelligence (AI) represents the next, higher level of digital development, which has become a key enabler of data-driven decision-making, automated process control, and business innovation. According to Eurostat data for 2024, 13.5% of EU companies utilise at least one AI technology, representing a 5 percentage point increase from 2023. At the same time, growth is highly differentiated according to the size, sector, and region of companies – the adoption of AI among small and medium-sized enterprises remains limited, primarily focusing on applications that enhance operational efficiency.

Broken down by company size, the data clearly indicate size-dependent digital differences. Only 11.2% of small companies (10-49 employees) adopted AI solutions in 2024, an increase from 6.4% in 2023, but still below the 41.2% share of large companies in the EU. For mid-sized companies, AI usage has increased to 21%, indicating the most dynamic growth in this category. This suggests that the main barrier to the adoption of AI technologies by smaller businesses is not the availability of technology, but rather the lack of infrastructure, human resources, and data capacity. Indeed, the effective use of AI requires prerequisites – such as digitised processes, structured data, and cloud storage solutions – that are not yet common among SMEs.

The application purposes of AI technologies also differ according to the size of the companies. Small and medium-sized businesses primarily use AI to support operational and customer relationship processes, such as marketing automation, customer service chatbots, financial administration, or IT security analysis. These areas represent low-risk investments that yield quick returns and can lead to immediate efficiency gains. In contrast, large enterprises typically utilise AI strategically – for example, through machine learning in production, predictive maintenance, supply chain optimisation, or support for research and development activities. Thus, AI primarily functions as a reactive tool in the operations of smaller companies, whereas it serves as a proactive tool in the operations of larger ones.

Based on Eurostat's thematic breakdown, the types of AI applications also deeply reflect differences in the level of development of companies. The use of machine learning (NLP) is around 3-5% for small businesses, while it is over 20% for large companies. Image recognition systems and autonomous decision-making technologies are still relatively rare among SMEs, particularly in the manufacturing and logistics sectors. This difference suggests that the majority of small businesses utilise ready-made, integrated AI solutions (such as SaaS-based marketing or administrative systems). At the same time, large companies employ proprietary, data-driven algorithms that serve as strategic tools for competitive advantage. Sectoral differences are also decisive in patterns of AI use. According to Eurostat data from 2024, the use of artificial intelligence is most prevalent in the information and communication technology (ICT) sector, where nearly half (approximately 45%) of businesses utilise at least one AI solution. There is also a high level of adaptation in professional, scientific, and technical activities (approximately 35-40%), which can be attributed to knowledge-intensive, data-driven operations. In contrast, the share of AI use in manufacturing, construction, and transportation is below 10%, indicating a lack of digital maturity and reliance on data-intensive processes. Figure 3 also illustrates that the introduction of AI technologies is primarily concentrated in information- and knowledge-intensive sectors, whereas the pace of adoption is slower in traditional industries. This difference is partly due to differences in data availability, technological culture, and digital competencies, which are particularly decisive factors for SMEs. The differences stem in part from the fact that AI adoption is closely related to data availability, technological culture, and the presence of digitised processes. Knowledge-intensive sectors, where the production of a service or product is inherently data-driven (e.g., IT development, research, consulting), integrate AI more easily and quickly than traditional industries, which typically focus on production-oriented innovation rather than data-driven approaches.



3. Figure Sectoral distribution of AI use in the EU, 2024

source: Eurostat, based on (Eurostat, 2020)

At the regional level, the geographic pattern of your AI app is strongly reminiscent of the trends seen in cloud usage. The Nordic countries (Denmark, Sweden, Finland) and Western Europe (Belgium, the Netherlands, Luxembourg) are at the forefront, where the share of companies using AI ranges from 20% to 28%. At the same time, in Eastern and Southern European Member States such as Hungary, Romania, or Bulgaria, the figure remains around 5-8%. Thus, regional differences cannot be interpreted in isolation, but in the context of the level of development of digital infrastructure, the prevalence of cloud computing, and corporate culture. AI and cloud-based technologies form a mutually reinforcing system: the cloud provides the data and computing capacity necessary for artificial intelligence to function, and the cloud becomes more valuable and intelligent through the application of AI.

Based on the results, it can be stated that the AI adaptation of SMEs is currently in the development phase, but not yet in the breakthrough phase. The majority of small and medium-sized businesses are aware of the potential benefits of AI technologies; however, their adoption is hindered by costs, a lack of expertise, and concerns about data security and reliability. However, the fact that AI usage increased significantly between 2023 and 2024 across all scale categories suggests that companies are increasingly recognising the competitive importance of innovative technologies.

Artificial intelligence is therefore not only a technological innovation for SMEs, but also a key to digital survival and long-term sustainability. Future competitiveness depends on small businesses' ability to integrate AI into their day-to-day operations, which requires a first step towards broader adoption of cloud infrastructure. The interdependent development of the cloud and AI will define a new era of the digital economy, in which SMEs cannot only be followers but also potential shapers of technological innovation.

#### 4.3. The links between AI and cloud computing in the digitalisation of SMEs

Cloud computing and artificial intelligence (AI) are emerging as mutually reinforcing and complementary technologies in the digitalisation process of European companies. Eurostat data for 2023-2024 clearly show that businesses already using cloud-based solutions are significantly more likely to have also adopted AI technologies. This correlation is not merely a statistical correlation, but a manifestation of a digital maturity chain: cloud-based infrastructure creates the technological, data,

and organisational foundation without which the application of AI can be implemented only to a limited extent or not at all.

Cloud computing can be understood as a prerequisite for AI to function effectively, as it ensures the storage, processing, and secure access to large amounts of data, while also offering scalable computing capacity. AI systems, particularly machine learning and predictive algorithms, require continuous data flow and processing, which is typically not feasible for SMEs with traditional local infrastructure. Cloud solutions, on the other hand, offer a low-cost, flexible, and service-based infrastructure that enables small and medium-sized businesses to access AI development and services – often in a software-as-a-service (SaaS) model. In this way, cloud technology is a kind of "gateway" to AI, democratizing access to advanced digital solutions.

However, the relationship between the two technologies is not only technical, but also strategic and economic in nature. Businesses that have already incorporated cloud services into their operations are more likely to have a data-driven decision-making culture, a prerequisite for effective AI use. Such companies typically follow a data-driven strategy, are more open to innovation, and have stronger digital competence. The introduction of AI is therefore not an isolated step, but a higher phase of a digital transformation process that emerges from the existence of cloud-based infrastructure. The level of cloud usage can thus also be indirectly interpreted as an indicator of AI adoption, especially in the SME sector.

Statistical data also support this synergy numerically. According to Eurostat data, in countries where cloud adoption rates exceed 60% among companies (e.g., Denmark, Sweden, Finland, the Netherlands), the share of companies utilising AI also reaches 20-25%. In contrast, in regions where cloud computing usage is around 30-40% (e.g., Hungary, Romania, Bulgaria), the rate of AI adoption is just over 6-8%. This connection is not accidental: the level of development of digital infrastructure fundamentally determines whether a company can take advantage of the opportunities inherent in AI technologies. Where cloud-based solutions are routinely employed, the technological and organisational barriers to AI integration are significantly lower.

The relationship between cloud and AI can also be interpreted as levels of development in the digital maturity model of SMEs. The first level involves digitised administration and cloud-based data storage, followed by online management of operational processes and the implementation of automated solutions. The second level is operation-based on data analysis, where AI is already emerging as a tool for decision support and efficiency optimisation. The third, highest level is predictive and adaptive operation, where AI becomes an integral part of strategic decision-making. The vast majority of SMEs are currently located at the first or second level; however, the expansion of cloud usage is gradually creating the conditions for more businesses to move towards AI integration.

At the same time, the synergy between the two technologies also raises new challenges. AI solutions built on cloud systems also raise data security, privacy, and ethical issues, especially among small businesses where cybersecurity capabilities are limited. Additionally, service dependency and a lack of digital competencies can increase the vulnerability of small businesses. One of the key questions at this stage of digitalisation is therefore not only the extent to which SMEs adopt new technologies, but also the awareness, security and strategic approach with which they do so. We can conclude that AI and cloud computing technologies play a complementary role in the digitalisation development of SMEs. The cloud provides the operational foundation and data availability, and AI provides a higher level of value creation and competitive advantage. SMEs that are able to use these two technologies synergistically can not only become more efficient, but also active shapers of the digital economy of the future. On the other hand, businesses that continue to fail to integrate these solutions may face a gradual erosion of competitiveness in the long term. Cloud infrastructure and AI technologies are therefore not just technological tools, but an ecosystem for the digital survival and development of SMEs, which determines the ability of companies to innovate, their flexibility and their contribution to economic growth in the European Union. The results of the study clearly show that the level of digitalisation of small and medium-sized enterprises (SMEs) in Europe is growing dynamically; however, significant differences remain in terms of company size, sectoral specifics, and geographical location. The use of cloud computing and artificial intelligence (AI) is spreading among

both SMEs; however, there is a temporal and structural difference in the prevalence and depth of integration of these two technologies.

The adoption of cloud-based services has accelerated significantly in recent years: in 2024, 41.7% of small companies, 59% of medium-sized companies, and 77.6% of large companies utilised some form of cloud computing solution. This indicates that cloud technology has become one of the pillars of digitalisation, making advanced data management and IT infrastructure accessible to SMEs. On the other hand, the use of artificial intelligence technologies is at a much lower level: only 11.2% of small companies, 21% of medium-sized companies and 41.2% of large companies use some kind of AI solution. Although growth is dynamic in all three scale categories, data suggests that AI adoption is still in its early stages and is primarily limited to pre-packaged applications to automate operational processes.

One of the most significant findings of the analysis is that AI and cloud computing technologies have a complementary relationship with each other: cloud-based infrastructure provides the data and computing capacity necessary for AI to operate, while AI generates a higher level of business value by analysing data stored in the cloud. This link is vital for SMEs, where technological developments often take place in a modular manner with limited resources. Cloud technology is therefore not just an IT solution, but a digital springboard towards AI integration, which allows smaller businesses to enter the era of data-driven operations.

However, regional and sectoral differences remain significant. In Nordic and Western European countries, the majority of companies have already integrated both technologies into their operations. In contrast, the pace of adoption in Eastern and Southern European Member States is slower, and the level of digitalisation of SMEs is below the EU average. The differences are due to the level of infrastructure development, the technological orientation of the education system, the level of digital competencies, and the differences in national support policies. It follows that ensuring access to technology is not sufficient to achieve digital convergence in the EU; it is also necessary to strengthen human and institutional conditions.

## Summary

The aim of this study was to explore the extent and structure of cloud computing and artificial intelligence (AI) technologies used by small and medium-sized enterprises (SMEs) in the European Union, and to examine how these two digital solutions contribute to increasing the digital maturity and competitiveness of companies. The analysis was based on official Eurostat statistical data for the period 2018-2024, using a descriptive and comparative methodology.

The results clearly show that the use of cloud services has become one of the fastest-growing trends in digitalisation in the EU in recent years. While in 2018 only a quarter (26%) of businesses used some form of cloud service, by 2023 this share had risen to 45.2%. However, the growth is not uniform: the cloud usage rate of 77% for large enterprises is more than double that of small companies, indicating that economies of scale, investment opportunities and human resources remain key drivers of digital transformation. At the same time, cloud infrastructure has gradually become a "core technology" that is essential for data-driven operations, collaboration and integration with more advanced technologies such as AI.

The spread of artificial intelligence, on the other hand, is still in its early stages, but has accelerated spectacularly in recent years. In 2024, 11.2% of small businesses, 21% of midsize companies, and 41.2% of large companies used at least one AI technology. According to the data, AI use is not only size-dependent, but also highly sector-dependent: the highest adoption can be observed in the fields of information and communication technology (ICT) and professional, scientific and technical services, while the share of AI use in manufacturing and construction remains below 10%. This difference suggests that AI integration requires data availability, digitised processes, and a technological culture — which are typically found in knowledge-intensive sectors.

One of the most important findings of the study is that cloud computing and AI technologies work in close synergy with each other. Cloud infrastructure provides the data storage, processing, and

scalability necessary for AI to function effectively, while the application of AI enhances enterprise value creation by analysing and automating data stored in the cloud. SMEs that already have cloud-based back-end systems are more likely to be able to implement AI-based solutions, which makes cloud technology one of the key indicators of digitalisation maturity.

Furthermore, regional studies indicate that the level of development of digital infrastructure and the quality of human capital have a significant impact on the pace of technological adaptation. In Nordic and Western European countries, the use of cloud computing and AI is already widespread, whereas the pace of development is slower in Eastern and Southern European regions. In this respect, Hungary ranks below the EU average, especially in the area of AI integration, partly due to limited digitalisation skills and partly due to limited investment capacities.

To summarise the research, it can be said that the digitalisation development of SMEs can be interpreted as a multi-stage process. The first phase involves the construction of cloud-based infrastructure, the second level is the development of data-driven operations, and the third is the strategic integration of artificial intelligence. To achieve the EU's future digital convergence, policymakers need to support not only access to technology but also the development of the knowledge base and the strengthening of digital competences. The competitiveness of the future depends on the ability of SMEs to integrate cloud and AI technologies into their operations in a complementary way and with a strategic approach.

## References

- Al-Sharafi, M. A., Iranmanesh, M., Al-Emran, M., Alzahrani, A. I., Herzallah, F., & Jamil, N. (2023). Determinants of cloud computing integration and its impact on sustainable performance in SMEs: An empirical investigation using the SEM-ANN approach. *Heliyon*, *9*(5), e16299. <https://doi.org/10.1016/j.heliyon.2023.e16299>
- Bianchini, M., & Lasheras Sancho, M. (2025). *SME digitalisation for competitiveness*. <https://doi.org/10.1787/197e3077-en>
- Brávác, I., & Krebsz, R. (2021). A magyar kis- és középvállalkozások digitális fejlettsége : Lehetünk-e digitális élvonalak? *Külgazdaság*, *65*(9–10), 60–85. <https://doi.org/10.47630/kulg.2021.65.9-10.60>
- da Silva, A., de Almeida, I. D., Dionisio, A., Rabadão, C., & Capela, C. (2025). How digital technologies enhance competitiveness in manufacturing SMEs. *Journal of Innovation and Entrepreneurship*, *14*(1), 103. <https://doi.org/10.1186/s13731-025-00576-8>
- European Investment Fund. (2024). *EIF Working Paper 2024/101 – SME Access to Finance in Europe 2024*. [https://www.eif.org/news\\_centre/publications/eif-working-paper-2024-101.pdf](https://www.eif.org/news_centre/publications/eif-working-paper-2024-101.pdf)
- Eurostat. (2020). *More and more employees use business mobile devices*. <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20200417-1>
- Eurostat. (2025a). *Cloud computing services by the size class of enterprise*.
- Eurostat. (2025b, 2 November). *Artificial intelligence*. [https://ec.europa.eu/eurostat/statistics-explained/index.php?Title=Glossary:Artificial\\_intelligence\\_\(AI\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?Title=Glossary:Artificial_intelligence_(AI)).
- González-Varona, J., López-Paredes, A., Poza, D., & Acebes, F. (2021). Building and development of an organisational competence for digital transformation in SMEs. *Journal of Industrial Engineering and Management*, *14*(1), 15. <https://doi.org/10.3926/jiem.3279>
- Harsányi, D., Totth, G., Szabó, Z., & Brávác, I. (2022). Analysis of Hungarian SMES' websites using a novel evaluation system. *Budapest Management Review*, *32*(8), 162–176. <https://doi.org/10.14267/V>
- Le Dinh, T., Vu, M.-C., & Tran, G. T. C. (2025). Artificial Intelligence in SMEs: Enhancing Business Functions Through Technologies and Applications. *Information*, *16*(5), 415. <https://doi.org/10.3390/info16050415>
- Lengyel, P., Pancsira, J., & Füzési, I. (2025). Application of Artificial Intelligence in Businesses: A Bibliometric Review. *Journal of Agricultural Informatics*, *16*(2). <https://doi.org/10.17700/jai.2025.16.2.782>
- Lu, H., & Shaharudin, M. S. (2024). Role of digital transformation for sustainable competitive advantage of SMEs: a systematic literature review. *Cogent Business & Management*, *11*(1). <https://doi.org/10.1080/23311975.2024.2419489>

- Mkhize, A., Mokhothu, K., & Tshikhotho, M. (2024). *Evaluating the Impact of Cloud Computing on SMEs Performance: A Systematic Review*. <https://doi.org/10.2139/ssrn.4958848>
- Mousa, K., Zhang, Z., Sumarlah, E., & Hamdan, I. K. A. (2024). The Impact of Cloud Computing Adoption on Firm Performance Among SMEs in Palestine. *International Journal of Intelligent Information Technologies*, 20(1), 1–24. <https://doi.org/10.4018/IJIT.338715>
- OECD. (2021). *The Digital Transformation of SMEs*. OECD. <https://doi.org/10.1787/bdb9256a-en>
- Ognjanović, I., Šendelj, R., Daković-Tadić, M., & Kožuh, I. (2024). A Longitudinal Study on the Adoption of Cloud Computing in Micro, Small, and Medium Enterprises in Montenegro. *Applied Sciences*, 14(14), 6387. <https://doi.org/10.3390/app14146387>
- Oluwafemi Clement Adeusi, Yusuf Olalekan Adebayo, Praise Ayomide Ayodele, Tajudeen Tunde Onikoyi, Kayode Blessing Adebayo, & Ibrahim Oyeyemi Adenekan. (2024). IT standardisation in cloud computing: Security challenges, benefits, and future directions. *World Journal of Advanced Research and Reviews*, 22(3), 2050–2057. <https://doi.org/10.30574/wjarr.2024.22.3.1982>
- Sándor, Á., & Gubán, Á. (2021). Digital maturity lifecycle model for SMEs. *Budapest Management Review*, 52(11), 57–70. <https://doi.org/10.14267/V>
- Segarra-Blasco, A., Tomàs-Porres, J., & Teruel, M. (2025). AI, robots and innovation in European SMEs. *Small Business Economics*, 65(1), 719–745. <https://doi.org/10.1007/s11187-025-01017-2>
- Szabó, Z. R., Szedmák, B., & Tajti, A. (2021). A hazai kis- és középvállalkozások digitális fejlettsége és külpiaci tevékenysége közötti kapcsolat néhány kérdése. *Külgazdaság*, 65(11–12), 3–27. <https://doi.org/10.47630/KULG.2021.65.11-12.3>
- Yousef, D. A. A., AlKhazali, Z., Qawasmeh, R. A., & Alshamayleh, H. Z. (2023). Medical invention marketing strategies on buying: Surgical medical robot. *International Journal of Data and Network Science*, 7(2), 647–656. <https://doi.org/10.5267/j.ijdns.2023.3.007>