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INTRODUCTION

In the 21st century, digital technologies have become a key driver of global economic transformation. Among the sectors most affected by this digital shift are organized commodity markets, which play a crucial role in facilitating the global exchange of goods and resources. The digitalization of these markets represents not only a technological transition but also a strategic imperative for economic competitiveness and sustainability. Organized commodity markets serve as structured platforms for the standardized trading of goods. Their operation relies on transparency, reliability, and access to timely information.

Digitalization is no longer just a technical upgrade—it's a strategic necessity. It changes how markets function, how trades are executed, and even how prices are formed. Electronic trading platforms, blockchain technologies, and real-time data analytics are no longer just innovations—they're becoming the standard. For businesses and economies, this evolution opens up new opportunities but also introduces new challenges

This diploma work aims to explore the current state, and future prospects of digitalization in organized commodity markets within international trade. The first section will provide a conceptual framework and overview of digital technologies, focusing on their impact on commodity trading. The second section will analyze international experiences and national strategies, with particular attention to Ukraine's digital transformation efforts and the broader global landscape. By examining best practices and identifying emerging trends, this study will contribute to understanding how digitalization can be effectively leveraged to support inclusive and sustainable development in global commodity markets.

The research is particularly relevant in the context of increasing globalization and technological advancement, where countries must adapt to digital realities to remain competitive. Understanding the dynamics of digital transformation in commodity markets is essential for policymakers, business leaders, and academics working to navigate and shape the future of international trade.

Among the most prominent representatives of economic thought who have devoted their works to the theory of the cycle are: Jean Charles Léonard de Sismondi, Karl Marx, Joseph Schumpeter, John Maynard Keynes, Nikolai Kondratiev, Wesley Clair Mitchell, Frédéric Hayek, Paul Krugman.

The following methods were used in the research process: analysis and generalization of scientific sources - for theoretical substantiation of the topic; comparative analysis - for studying national and international experience of digitalization; systemic approach - for a comprehensive assessment of the impact of digital technologies on organized commodity markets; statistical analysis - for processing actual data; and graphical method to reflect the development of economic processes in the world and Ukrainian economies

The work consists of an introduction, two chapters, a conclusion, a list of sources used, and appendices.

CHAPTER 1.

The concept and evolution of digitalization

1.1. Defining the essence of the concept of digitalization and its role in organized commodity markets

The world economy with their markets is developing under the influence of numerous factors, among which the decisive place is occupied by information and communication technologies. Digitalization of economies significantly increases the level of their competitiveness in the international market and fundamentally changes business processes in the international business environment.

Digitalization is developing at an incredible rate due to its ability to collect, use and analyze huge amounts of information (digital data) about almost everything. Such digital data is collected through the analysis of “digital footprints”, that are left on various digital platforms as a result of the activities of individuals, social groups or businesses. Digitalization improves decision-making by enabling businesses and governments to predict trends with the latest technology and analytics, increase efficiency with artificial intelligence automation, and strengthen cybersecurity with digital identity verification and blockchain technology.

In scientific and analytical works that study the processes of digitalization and their development in modern society, there are a significant number of concepts for understanding the content of digitalization. Due to the constant changes in the digital industry, there is no recognized and accepted single definition of digitalization does not exist. Digitalization covers technological operations of trade in goods and services that can be carried out both online and physical, involving consumers, entrepreneurs, firms, and governments. Quite often, the digital economy is identified with the “network” or “information economy”. In the modern literature, there are several approaches to defining the essence of digitalization, most often it means “digitization” or “digitalization”. Consider

several definitions of digitalization from leading scholars and experts in the field of global economy and digitalization (table 1.1).

Table 1.1 – The main approaches to understanding definition “digitalization”

Definition of digitalization by different scientists	
George Westerman	"Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business."
Scott Brennen and Daniel Kreiss	"Digitalization refers to the adoption or increased use of digital or computer technology by an organization, industry, or country."
Neely Crawford	"Digitalization is the process of transitioning from analog to digital processes, enabling organizations to enhance efficiency and create new opportunities."
Tim O'Reilly	"Digitalization is the use of digital technologies to change the way work is done and customer services are delivered, allowing organizations to adapt to market changes."
Klaus Schwab	"Digitalization is the integration of digital technologies into all aspects of human life, leading to fundamental societal changes."
Linda Schneider	"Digitalization is the process of converting information into a digital format, enabling its processing, storage, and transmission through digital technologies."
Michael Wade	"Digitalization is the application of digital technologies to optimize business processes and create new growth opportunities."
Erik Brynjolfsson and Andrew McAfee	"Digitalization is the transformation of all types of information into digital formats, enabling its processing and analysis by computer systems."
David Rogers	"Digitalization is the process of using digital technologies to create new value in business models, customer experiences, and internal capabilities that support core operations."

Structured and analyzed by the author from various sources

In order to better understand the definitions, let's look at the common and distinctive features of the authors' definitions:

Common: 1. Use of digital technologies to transform business, processes, or society.

2. Integration of digital technologies to create new opportunities and increase efficiency.
3. Changing traditional processes towards digitalization.

Distinctive: 1. Focus on different aspects of the concept: business models, information systems, customer experience, or social change. 2. Basis on technical, social or cultural aspects. 3. Attention point on different scales: from a local organization to a global society.

To better understand the topics of the studies and the basis for their conclusions, let's take a closer look at their findings in the studies behind their claims:

George Westerman [1] a researcher from the MIT Sloan School of Management found that companies that successfully implement digital technologies are 2 times more efficient than their competitors. In his research, he emphasizes that digital transformation is not just the introduction of technology, but a change in the business model. Scott Brennen & Daniel Kreiss are the authors of the study “Digitalization and Digitization” [2], which explained the difference between digitalization and digitization. They proved that digitization is only a technical process, while digitalization covers global changes in the economy, society and politics. Neely Crawford [3] researches business efficiency through digital technologies. One of her main conclusions is that companies that move faster to digital processes reduce operating costs. She also analyzes the impact of ERP systems on the efficiency of enterprise management.

Tim O'Reilly [4] is known as the founder of the term “Web 2.0”, which describes a new phase of Internet development - from static websites to interactive platforms (social networks, marketplaces). Klaus Schwab [5] is the founder of the World Economic Forum believes that automation and artificial intelligence could displace up to 30% of jobs in the next 10-15 years. He also emphasizes the importance of regulating digital technologies to avoid social inequalities. Linda Schneider explores the role of Big Data in the digital economy. Her work has proven that the use of big data in business increases the accuracy of forecasting market trends. She also analyzes how digital technologies affect

cybersecurity and personalization of customer experience [6]. Michael Wade founds that companies that do not implement digital innovations can lose up to 50% of their market share within 5 years [7]. Erik Brynjolfsson & Andrew McAfee predict that digital technologies will contribute to the growth of income inequality. They proved that automation and AI can increase productivity by up to 40% in the next 10 years, but require retraining of workers [8]. David Rogers is the author of «The Digital Transformation Playbook», in which he identified 5 key digitalization strategies. He argues that digital transformation is not only about technology, but also about changing the way companies think [9]. Analyzing the above works of leading national scientists, the author created a new definition of digitalization: Digitalization is a global process of digital evolution and transformation, covering all spheres of economy, business and society.

Digitalization is a technology for the development of modern society in a neo-economy (new economy). It is designed to simplify, accelerate, and modernize work with large amounts of data, automate all types of activities (operational, investment, and financial), improve communication with customers, suppliers, and partners, and all external institutions, form new principles of interaction within the enterprise - between departments, employees, and management, and facilitate the transition to new organizational forms of management (network and virtual economy).

Digitalization contributes to the expansion of the information space by creating new information products, helps to reduce information costs and accelerates the development of digitalization of society. It significantly accelerates and simplifies the search for information, its exchange, and helps to strengthen cooperation between companies, people's search for favorable living conditions, and the quality of interaction between the country's population and its government. An example of government-society interaction is the Ukrainian development of digital documents called Diia, which combines a mobile application and a public service portal. In the direction of ensuring sustainable development

of society, digitalization is a necessary process that minimizes resource costs, directing their use in areas that require it and mobilizing resource potential for further development.

Digitalization is part of the new economy (neo-economy)[10] - a new type of socio-economic system that is gradually being formed within the post-industrial period of economic development through the introduction of scientific and technological progress and innovative methods of management, intellectualization of human capital, the use of advanced new technologies, accelerated development of knowledge-intensive sectors of the economy, prioritizing to the production of knowledge and services, and the formation of a creative efficient, rational business. The economic infrastructure of the neo-economy is characterized by the predominance of intangible assets (knowledge, services) over tangible ones. The new economy is being formed on the basis of not only the intellectualization of production, but also the entire economic life, on the basis of the widespread use of information and communication technologies.

The digital economy should serve the interests of the majority, not a narrow circle. There is no deterministic beginning in financial technologies. Digitalization in the commodities markets exist in several ways, spot markets and forward transactions, as well as other derivatives contracts such as options, there are organized exchanges and over-the-counter markets, physical and financial aspects. Trading takes place in many different geographical locations and many different commodities and grades of those commodities are traded. While the use of automated tools in financial markets has increased, the commodities sector continues to experience low levels of innovation and adoption. One of the reason is that physical commodities such as oil and LNG are traded in the spot market, fundamentally different from trading stocks in secondary markets.

Commodity market participants embrace new technologies such as machine learning and Blockchain to improve the storage, logistics, and transaction of physical commodities, significantly increasing market efficiency and transparency. However, to fully leverage these technologies, businesses must first digitise their data and workflows:

the primary benefit of digitalisation in commodities is the ability to extract insights through data analysis, obtain real-time business information, and reduce costs – all of which are considerations in a market with extremely thin margins. Big data and predictive algorithms enhance the rigour and accuracy of fundamental analysis, while information specialists provide structured data directly to trading systems.

International relations in all key areas of society have entered a qualitatively new stage of development, which requires the emergence of new means of communication, including technologies for influencing the level of public awareness. New requirements, challenges and risks that arise during the adaptation phase are inextricably linked to the process of creating new technologies. Having analyzed the analytical reports of the World Economic Forum[11], we can identify the main digital technologies (fig.1.2.)

Artificial Intelligence (AI)	• A set of technologies that enable computers to perform a variety of advanced functions, including the ability to see, understand and translate spoken and written language, analyze data, make recommendations. Used in healthcare for disease diagnosis (USA), in finance for fraud detection (UK), and in transportation for autonomous vehicles (China)
Internet of Things (IoT)	• The collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. Include smart thermostats and kitchen appliances, fitness-tracking watches, self-driving cars, and home security systems.(USA)
Blockchain	• A distributed database that maintains an ever-growing list of ordered records called blocks. The use of digital currency in El Salvador, supply chain tracking (Australia) and secure voting (Estonia).
5G Connectivity	• The wireless technology is meant to deliver higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Good example is smart factories (South Korea), remote surgery (USA), and autonomous vehicles (Japan).
Cloud Computing	• The delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet (“the cloud”) to offer faster innovation, flexible resources, and economies of scale for data storage for government services (Canada) and business innovation (India).
Cybersecurity Innovations	• Are improving the ways organizations protect their assets, privileged data, and employees. In the USA, AI-driven systems detect and prevent cyberattacks. Israel leads in cybersecurity startups offering advanced encryption and threat intelligence.

Fig 1.2. The main digital technologies

Source: structured by the author based on [12]

The digital economy refers to the economic activities that emerge from connecting individuals, businesses, devices, data and operations through digital technology. It can be viewed from two perspectives: firstly, it is a set of new industries that constitute the majority of the global economy, and secondly, as economic production that uses digital technologies that transform some aspects of business entities that are already established in their

activities. Thus, digital technologies, which are the basis of the digital economy, significantly affect the quality of life of citizens and ensure economic growth of the country, and their implementation in various sectors of the economy and levels of production actually leads to significant economic benefits, which are expressed, among other things, in GDP growth.

The components of digitalization are cyber-physical systems, the Internet of Things, big data, robotics, 3D printing. Cyber-physical systems (CPS) are a component of business digitalization, reflecting a mechanism operating on the basis of computer algorithms, connected to the Internet and users. The main idea of CPS is to develop ways to receive and provide various information, communicate with other devices via Internet access, and extend software using mobile applications.

The Internet of Things (IoT) is a network of interconnected objects (things) that have built-in data, software that provides the ability to transmit and exchange data between the physical world and computer systems via personal or Internet networks. Big Data – structured and unstructured data of large volumes, processed by scalable software tools: big data management technologies (SQL, NoSQL, Hadoop); data mining, web mining; machine learning; construction and use of data warehouses. Robotics are robotic systems designed to automate technological processes, aimed at the design, development, construction, operation

Since 2014, the European Commission has been monitoring the progress of Member States in the field of digital technologies and publishes annual reports on the Digital Economy and Society Index (DESI)[46]. Each year, the reports include country profiles that highlight priority areas of action for key Member States, as well as thematic sections that present EU-level analysis in key digital policy areas and the use of robots; implementation of control by computer systems, feedback, information processing of automated technical systems. 3D printing is a technology that allows you to create a three-dimensional object by applying successive layers of material according to the data of a

digital model. This technology is carried out using a 3D printer, which provides a process of design modeling using visual and graphic tools.

The listed components of digitalization are most characteristic of enterprises involved in the service sector, but can be applied in various sectors of the economy, the main ones being: chemical, food, processing, automotive, shipbuilding, metallurgical engineering, agriculture. DESI is the index that the European Commission produces to monitor member states' digital progress on an annual basis. DESI includes individual country profiles, showing analysis of progress against the key indicators as well as areas requiring priority action by member countries.

Digitalization, as a process of deep implementation of digital technologies in all spheres of social life, has become a defining feature of the modern stage of economic development. Defining the essence of this phenomenon encompasses not only technical modernization, but also changes in approaches to doing business, interaction between economic agents, and the principles of organizing commodity markets. Digitalization is also a tool for ensuring the stability and innovative flexibility of product markets.

Thus, digitalization is a key factor in the transformation of modern commodity markets, ensuring their transparency, speed, efficiency and adaptability to global changes. It contributes to increasing the competitiveness of enterprises, optimizing operational processes and improving interaction between all market participants.

1.2. The evolution of digital technologies and their impact on the efficiency of commodity markets

Digital optimization of economic and production processes is considered as the main prerequisite for the development of innovative activity in the field of trade, it can be argued that digitalization has significantly expanded the scope of its functioning today, becoming a basic element of the market system. At the same time, scientists note that increasing the productivity of enterprises-market players on the basis of digitalization involves the gradual and effective achievement of goals, which include optimizing the overall financial and economic condition, effective resource saving, effective use of assets, strengthening the status in the market in a sustainable economy, the formation of high functionality indicators through the stabilization of resource reserves and the use of risk insurance opportunities.

In digital optimization, each customer-facing team—product, marketing, customer success, engineering, analysts, and more—should cycle through the insight, action, and outcome phases to turn product data into tangible growth. With each new insight comes an opportunity to drive a valuable business outcome. With each outcome comes more data to provide deeper insights.

The emergence of digital history is a response, first, to advances in digital technology over several decades, and second to changes in the discipline of history itself. The anthropological and post-structuralist turn in history – which gave rise to new theoretical and methodological emphases has by now either been folded into or given way to a digital turn. New methods of collection, processing, storage, analysis, and publication have become standard in contemporary historical research. With the advent of the first digital devices at the end of the 20th century, the irreversible process of digitalization was launched. And with the advent of the Internet and smartphones, it has

become widespread. Let's analyze the evolution of digital technology development and their impact on the digitalization of the economy (table 1.3.)

Table 1.3. The evolution of digital technology development and their impact on the digitalization of the economy

The period	The key inventions and digital technologies	Impact on the economy and commodity markets	Countries leading implementation
Primary 1991-2010	The emergence of the first electronic payment systems revolutionized online transactions, simplifying the processes of money transactions and making them more efficient. At the same time, the development of electronic wallets and cards for cashless transactions has brought a new level of convenience and speed to financial interactions, unlocking the potential of digital technologies in solving money transaction issues. Blockchain is a technology that enables transparent and tamper-proof data storage. Initially introduced with Bitcoin (2008) by Satoshi Nakamoto	Blockchain has increased efficiency through secure cross-border transactions, financial inclusion, and real-time supply chain tracking, by reducing transaction costs and eliminating intermediaries.	United States, China
Consolidation phase (2010-2015)	Mobile finance emerged, robo-advisors played a role in investment, innovative startups competed actively, and security and regulatory issues gained importance in light of the growth of digital transactions and the popularity of fintech solutions. This period laid the foundation for the further evolutionary development of financial technologies. According to the International Federation of Robotics, global sales of industrial robots doubled between 2013 and 2015.	Robotics is aimed at creating robots and robotic systems designed to automate complex technological processes and operations, in particular those performed in non-deterministic conditions, to replace humans in performing difficult, tiring and dangerous work.	China, Japan, Republic of Korea, USA and Germany
Fintech revolution (2015-2020)	This period is marked by the rapid growth of innovation and transformation that define the modern financial system. The emergence of new technologies, such as artificial intelligence, as well as the growing popularity of cryptocurrencies and decentralized financial services, makes this stage important for understanding the evolution of the	Cloud computing transforms traditional business models, reducing the need for in-house IT professionals and offering the flexibility to scale, deploy and maintain applications.	North America, Western Europe

	financial sector through digital transformation. Cloud computing is a paradigm in which information is permanently stored on servers on the Internet and temporarily cached on the client side, for example on computers, smartphones.		
Active Development 2020-present	The growth of digital banks, designed to provide a full range of financial services through online channels without the need for physical branches, indicates the desire for digital transformation of traditional banking services. At the same time, there is an integration of various fintech technologies into a single ecosystem, where different services and products merge into a single financial flow, simplifying users' access to a variety of financial solutions.	General purpose artificial intelligence technologies have the potential to increase the global economy by approximately \$13 trillion by 2030, with an additional 1.2% per year of GDP growth	China, the United States and Japan

Source: structured by the author based on [13]

According to the concept of digitalization, the most “digitalized” economy in the world at the moment is the US economy. In the economy of the one third (33%) of GDP is affected by digital technologies, and a large share (60%) of the of the US financial sector is digitized, making the US financial sector the most “digitalized” in the world. It is closely followed by the communications sector communications sector, which increases the importance of creating and maintaining a modern, sustainable digital platform for its long-term development. Thus, in the context of the high digitalization of the U.S. economy, which affects key sectors, the European Union, in turn, focuses on ensuring an open market economy, creating favorable conditions for international trade and innovation.

The first commodity traders to experiment with systematic trading across the full commodities chain were a few experiential power and gas utilities exploring parametric trading opportunities in physical intraday markets. These players typically armed mathematicians with Matlab or Python, gave them predefined parameters, and let them trade small positions with limited risk exposure.

Most of these efforts ultimately failed, partly because the companies lacked a technical understanding of the algorithms and the underlying technology but mainly because of limited support from company leadership, which often viewed the activities as curiosities rather than the beginnings of a structural shift in trading. Some commodity traders also started using algorithms to optimize the execution of hedging strategies—inspired by the success of investment banks in the equity-trading arena—but not with the primary aim of maximizing profits. The main principle of the EU trade strategy is to ensure an open market economy. The main principles of the current European trade strategy, among others, are:

- differentiation and personalized approach that ensures partnership with the EU and interaction with partner countries in their defined ambitions, capabilities and interests, to maximize the benefits of interaction; research and integration of more effective ways to implement reform goals in partner countries, based on synergy of efforts of public, social and economic formations;

- emphasis on the established circle of priorities and intensification of the role of common ownership, focusing on the joint efforts of EU Member States and partner countries;

- adaptability of the financial instruments used by the trade strategy, in order to increase the ability to respond to targeting external effects;

- openness and transparency of communication regarding the trade strategy, increasing the level of awareness of its results, which has a strengthening sphere of strategic communications [14]

The European Union (EU) has become a leader in embracing digital transformation, recognising it as a key driver for economic growth, competitiveness and societal well-being. The EU's approach to digital transformation is embedded in its comprehensive digital strategy, which aims to make the Digital Single Market a reality. This strategy is supported

by several key policy frameworks, including the Digital Europe programme and the Europe 2020 strategy. Andrus Ansip, former Vice-President for the Digital Single Market, played a key role in driving these initiatives forward, focusing on removing digital barriers in Member States and fostering digital innovation.

The digital single market strategy aims to ensure that Europe's economy, industry and society take full advantage of the new digital era. Alongside e-solutions and data, and cross-border digital services, it is an integral part of EU's project for a digital Europe. The EU has already started creating a free and secure digital single market in which people can shop online across borders and businesses can sell online across the EU. Proposed by the European Commission in 2015, the digital single market strategy laid the foundations of a united and sustainable European digital society.

A number of landmark achievements:

- the end of roaming charges;
- the modernisation of data protection;
- the cross-border portability of online content;
- the agreement to unlock e-commerce by stopping unjustified geo-blocking;

Going forward, this strategy seeks to further expand the EU's digital economy and tear down regulatory walls between the EU member states. The EU's approach to digital transformation is embedded in its comprehensive digital strategy, which aims to make the Digital Single Market a reality. Investment in digital infrastructure and innovation is at the heart of the EU's digital transformation agenda. The Connecting Europe Facility and the Horizon Europe programme are examples of the EU's commitment to improving high-speed internet access, promoting digital research and development, and supporting the digitalisation of public services [15]. These initiatives aim to increase the EU's competitiveness in the global digital economy and ensure that its digital infrastructure meets the needs of the digital single market.

The EU prioritizes data protection and cybersecurity as fundamental pillars of its digital strategy. The General Data Protection Regulation (GDPR) serves as a global benchmark for data privacy, ensuring that personal data is handled securely and transparently. Additionally, the EU Cybersecurity Act strengthens the security framework across member states and enhances cooperation in responding to cyber threats. The EU also emphasizes digital literacy and skills development to bridge the digital divide and foster innovation. Initiatives such as the Digital Education Action Plan aim to equip citizens with the necessary skills to thrive in a rapidly evolving digital economy. Furthermore, the European Digital Innovation Hubs provide support to small and medium-sized enterprises (SMEs) to help them adopt digital technologies and remain competitive.

By fostering collaboration between public and private sectors, the EU is building a resilient and inclusive digital ecosystem that promotes innovation, protects citizens' rights, and boosts economic growth. Digitalization is revolutionizing commodity trading by improving efficiency, transparency, and decision-making across the entire value chain. Trade execution has become faster and more efficient with algorithmic trading, which automates transactions based on pre-set conditions, reducing costs and improving market responsiveness. Smart contracts digitize agreements, minimizing settlement risks and enhancing trust among market participants. Real-time market data platforms provide instant access to bid and offer information, allowing traders to react quickly to market movements.

Risk management has also improved significantly with AI-driven predictive analytics that assess market volatility and portfolio exposure in real time. Regulatory technology (RegTech) automates compliance monitoring, ensuring adherence to regulations such as MiFID II and GDPR. Cybersecurity tools safeguard trading platforms from fraud, cyber threats, and unauthorized access. Supply chain management benefits from IoT and smart sensors that provide real-time tracking of commodities, optimizing logistics and reducing inefficiencies. Digital freight platforms streamline transportation routes,

cutting costs and improving delivery times. Predictive analytics help mitigate potential disruptions caused by weather conditions, geopolitical issues, or labor shortages.

Post-trade processes have become more efficient with automated reconciliation systems that match trade data accurately, reducing manual errors. APIs and digital interfaces facilitate seamless payment processing and settlements between traders and financial institutions. Cloud-based audits enhance financial transparency and ensure regulatory compliance. Indeed, commodity trading is on the cusp of the next normal. The energy transition now under way is an economic and physical transformation that cuts across and integrates the various global food, energy, and materials systems.

From a commodity trading standpoint, this transformation will increase structural volatility, disrupt trade flows to open new arbitrages, redefine what it means to be a commodity, and fundamentally alter commercial relationships. All these developments will create unique opportunities and challenges for new and incumbent players alike. As digital technologies continue to develop in strength, they will continue to transform the commodity trading value chain – before, during, and after a transaction (table 1.4.)

Table 1.4. – The influence of digitalization on different aspects

Aspect	Before Digitalization	After Digitalization
Securitization	Trades required manual negotiation by trading desks.	Financial products are pooled and traded instantly.
Investment Decisions	Traders spent significant time processing and normalizing diverse data sources.	Instant access to structured and predictive data for better supply-demand forecasting.
Position Generation	Decision-making was slower, less automated, and prone to errors.	Automated, real-time market visualization (e.g., Kensho), reducing costs and improving accuracy.
Portfolio Management	Limited risk assessment capabilities; manual tracking of market trends.	Cloud-based trading systems enable real-time risk assessment and scenario analysis.
Execution	Trades were sequential and often visible, impacting market prices.	Smart execution optimizes trades to reduce costs and minimize market impact.
After-Trade Process	Manual and slow post-trade processing.	Digitized back-office operations improve efficiency and relationship management.

Source: is created by the author based on the [16]

Digitalization has significant potential to improve the efficiency and development of both an individual enterprise and the economy, but the implementation of digital tools and technologies requires a careful approach to maintain a balance between benefits and risks. On the one hand, the integration of digital solutions enables companies to optimize internal operations, reduce transaction costs, enhance data-driven decision-making, and strengthen their positions in competitive markets. On the other hand, rapid technological advancement introduces challenges related to cybersecurity threats, regulatory compliance, uneven digital access, and the risk of overdependence on automated systems.

Therefore, enterprises and governments must develop comprehensive digital strategies that include robust security frameworks, continuous staff training, investment in digital infrastructure, and active stakeholder engagement. This dual focus on innovation and risk mitigation ensures that digital transformation contributes not only to short-term productivity gains but also to long-term economic resilience and sustainable development across the global commodity trade landscape.

1.3. Challenges and risks of digitalization of commodity markets

Digitalization of commodity markets encounters challenges in infrastructure, security, market transformation, and regulation. Studies examining various sectors report that integrating modern technologies with legacy systems and ensuring robust broadband availability are crucial. Cybersecurity threats and data protection issues are pronounced, particularly in banking and financial markets, where vulnerabilities have been linked to low financial literacy among individual investors. Nowadays, organizations, regardless of their field of activity, are forced to move along the inevitable path of digitalization for effective economic development. In global markets, this process provides the following competitive advantages for enterprises:

- Providing additional value to the product through high-quality digital service;
- High level of communication with customers and target audience through multi-channel platforms;
- Improving the company's image through fast and personalized communication with customers;

- Reducing costs through process automation and business process digitization;
- Transparency of internal and external processes through blockchain technologies and data management systems;
- Increasing customer loyalty through an individualized approach and big data analytics.

All changes taking place in the activities of enterprises lead to the transformation of service provision in global markets:

1. Improving the conditions for the convenience of e-commerce through integrated platforms and marketplaces;
2. Ability to make payments using cryptocurrencies and digital wallets;
3. Purchase goods without leaving home through augmented reality and virtual showrooms;
4. Evaluate goods using virtual reviews and feedback in real time;
5. Order goods at any convenient time and place through global logistics networks;
6. Mobile applications and chatbots provide 24/7 access to information and customer support in real time.

Innovative financial technologies have come a long way in development, so in Table 1.5. it is appropriate to offer the author's view on the periodization of the development of digitalization.

Table 1.5. The advantages and disadvantages of development of digitalization

<i>Advantages</i>	<i>Disadvantages</i>
Increased efficiency and productivity Automation of routine and repetitive tasks reduces the time and effort required to get the job done. The ability to store, process, and analyze large amounts of data improves decision-making. Accordingly, this allows businesses to reduce costs and increase production or service delivery	Cybersecurity and the threat of data loss With the increasing use of digital technologies, there is a threat of personal data leakage, hacker attacks and other cybercrimes; improper storage or processing of information can lead to serious consequences. The need to constantly update and improve security systems to protect against

	these threats is becoming an important component of digitalization
Cost reduction The implementation of digital technologies allows to reduce the costs of supply chain management, increase the accuracy of orders and reduce human resources costs. The transition to digital platforms allows to reduce the costs of paper, physical storage of documents and many other material resources, which also reduces the environmental impact by reducing the amount of waste.	Job losses Process automation can lead to job losses, especially in areas where people previously worked in routine or physical tasks, which can lead to increased unemployment among some groups of the population who lack the skills to work with new technologies.
Improving accessibility of services Digital platforms allow citizens and businesses to access services 24/7, regardless of geographical location, this is particularly important in healthcare, education, and government services.	Digital divide Not all citizens have access to the Internet or the necessary technologies, which can create inequalities in access to digital services, particularly in rural areas and among older people who do not always have the necessary digital skills. This can lead to social inequality.
Increased security and control Due to the use of digital technologies, information flows can be better controlled and fraud or abuse can be prevented; the implementation of an electronic document management system ensures transparency and data security.	Dependence on technology Increasing reliance on digital tools can be problematic, as any technical failure, cyberattack, internet outage or data loss can lead to significant problems with access to data and resources; losing access to important online services can have serious consequences, especially in the case of critical infrastructure.
Innovation and development of new business models Digitalization allows for the creation of new products and services that were previously impossible, and opens up new markets, promotes the development of startups and innovative technologies such as artificial intelligence and blockchain	Intellectual and ethical issues The use of big data and artificial intelligence can raise ethical issues related to privacy, data control, and decision-making autonomy. The technologies can affect people's personal lives and/or they can be used for manipulation.
Personalization of services and products The use of Big Data and artificial intelligence allows you to create personalized offers for customers, which helps improve the user experience and increase loyalty	The need for large investments For organizations, especially small and medium-sized businesses, the implementation of digital technologies requires significant financial and resource investments in the development, adaptation and support of digital solutions.
Rapid response to change Digitalization allows organizations to quickly adapt to market changes, monitor trends, change strategies based on data analysis, and automate processes to remain competitive.	Privacy and data protection issues With digitalization, the amount of data collected, stored and processed increases, which can violate users' rights to the protection of personal information. Without adequate data protection measures, privacy risks can arise, which can lead to legal and reputational problems.

Ensuring inclusion Digitalization can help ensure access to essential services (education, healthcare, financial services) for people with special needs, remote or marginalized populations, who previously did not have such access due to physical, geographical or economic barriers.	Technical complexity and the need for continuous learning Ever-changing technologies require employees to continually learn and adapt to new tools. This can create additional stress for staff and businesses.
Facilitating communication Rapid information flow between companies, clients, and partners allows minimizing the number of physical meetings, thus significantly saving the irreplaceable resource of time	Technology obsolescence The technological component of many innovative business models can quickly become obsolete, requiring regular investments in updates and modernization

Source: structured by the author based on [17]

Thus, throughout the stages of financial technology development, there is a continuous process of transformation of the financial sector from traditional to digital service models. The emergence of digital banks, integrated fintech ecosystems, as well as the introduction of innovative technologies indicate the rapid development of the industry, providing consumers with convenience and expanded opportunities in financial services.

The development of information technologies and systems has changed the roles of the participants in the field of commodity circulation. They are no longer passive; consumers, suppliers, analytical companies and other entities associated with the commodity supply chain have unlimited opportunities to receive and transfer information. While the use of automated tools in financial markets has increased, the commodities sector continues to experience low levels of innovation and adoption. One reason is that physical commodities such as oil and LNG (liquefied natural gas) are traded in the spot market, fundamentally different from trading stocks in secondary markets. In addition, the spot market involves trading large quantities of a physical commodity that must be financed, insured, stored, transported, and received. As a result, the entire commodity supply chain is subject to price volatility and risk.

Commodity market participants embrace new technologies such as machine learning and Blockchain to improve the storage, logistics, and transaction of physical commodities, significantly increasing market efficiency and transparency. However, to

fully leverage these technologies, businesses must first digitise their data and workflows: the primary benefit of digitalisation in commodities is the ability to extract insights through data analysis, obtain real-time business information, and reduce costs – all of which are critical considerations in a market with extremely thin margins. Big data and predictive algorithms enhance the rigour and accuracy of fundamental analysis, while information specialists provide structured data directly to trading systems. [18]

Bulk commodity trade involves a wide range of commodities, such as oil, natural gas, metals, agricultural products, etc., the prices and volumes of which have a significant impact on the global economy. In this area, trade participants are exposed to a wide range of risks, some of the main types. Price volatility risk Price fluctuation risk is the most common and major risk faced by bulk commodity trade. Bulk commodity prices are affected by a variety of factors such as supply and demand, geopolitics, monetary policy, weather changes, etc., and price fluctuations may lead to losses for traders. In the case of a bulk commodity price surge, upstream enterprises may refuse or delay shipments due to higher transportation costs, and may also risk defaulting on contracts already signed with downstream enterprises. When bulk commodity prices plummet, enterprises may bear the loss of the price drop due to holding inventory, which may lead to more serious floating losses if the inventory is large or measures such as price locks are not taken in advance. [19]

Liquidity risk Bulk commodity trade is of a large scale and has a high demand for capital. In the course of business operation, a large amount of liquidity is usually occupied, and because of the company's limited financial capacity, it usually carries out its trading activities by means of bank credit or short-term loans. Once the market fluctuates, when there is a decrease in the speed of turnover and difficulties in realizing the inventory, if the company fails to sell the inventory to recover the payment within the stipulated time, it cannot obtain sufficient funds in time to pay the debt due, which may lead to the need for the company to face liquidity risk.[20]

Credit risk refers to the risk of default, delayed debt repayment, loss of expenses, and difficulty in debt recovery due to poor credit qualification level of suppliers or customers.[21] For example, in the process of bulk commodity trade, the upstream suppliers are difficult to fulfill their payment obligations according to the terms of the contract and fail to deliver on time. Or the supplier's products do not meet the quality standards, which will result in a series of chain reactions such as unclear property rights, loss and destruction of inventory, insolvency of the partner, and finally caused a huge economic loss of the bulk commodity trade company. Today, as bulk commodity trade markets become digitized, their technology and network security risks are becoming increasingly prominent. For example, due to system failures, network attack, etc., they may lead to business interruption, data loss or leakage.

One of the primary challenges in digital commodity markets is the occurrence of technical issues. These can range from slow internet speeds and website crashes to software glitches and compatibility problems. Such technical difficulties can lead to delays, frustration, and even lost bids, significantly impacting the outcomes of digital auctions. Digital commodity markets are also vulnerable to cybersecurity threats. Online platforms can attract scammers who create fake listings or use phishing tactics to steal personal information or money from unsuspecting participants. Ensuring robust cybersecurity measures is essential to protect both buyers and sellers from potential fraud.

The lack of transparency in digital auctions can make it difficult for participants to determine the true value of commodities. This uncertainty can lead to overbidding or underbidding, resulting in less than ideal outcomes for both buyers and sellers. Building trust through transparent processes and clear information is crucial for the success of digital commodity markets. Unlike traditional auctions, digital platforms often do not provide opportunities for in-person inspection of commodities. This limitation can make it challenging for buyers to assess the condition and authenticity of items, potentially leading to disputes and dissatisfaction. Digital auctions also lack the personal interaction that is

often a part of traditional auctions. This absence can make it difficult for participants to ask questions or negotiate terms, potentially leading to misunderstandings and miscommunications.[22]

Analyzing the data provided digitalization of the public sector of the economy accelerates the process of managing budget revenues and expenditures, reducing the administrative burden and increasing the level of transparency. Digital transformation is already becoming an important tool in the fight for competitiveness and adaptation to modern realities. The key goal of digitalization for business remains to increase labor productivity and production efficiency. Confidence in the ability of technologies to improve operations and promote business growth is directly proportional to the size of the enterprise: the larger the company, the more it trusts innovations.

Chapter 2.

Digital transformation in the world and in Ukraine: international experience, national strategies and development prospects

2.1 Analysis of leading countries in the international market for the implementation of the latest technologies

According to the study by the Organization for Economic Co-operation and Development (OECD)[23], there are two main factors impacting the implementation of digital technologies. The first factor is the internal capabilities of an organization; the other factor provides driving digital transformation. Digital innovations create the necessary conditions for the development and implementation of other innovations aimed at product commercialization.

Accordingly, digital innovations act as drivers for ensuring the transformation of the internal environment in such a way that the initiated innovative processes in the production sector could achieve the required results. In order to monitor the speed of regions' development and how information technologies are implemented in them, it is necessary to find ways to reflect the readiness of the population to move to a new level of development. To this end, various research teams are trying to assess the level of the readiness of countries for the digital economy.

Comparisons were made with 5 measurements developed by the Digital Economy and Society Index (DESI): development of the broadband services market, human capital/digital skills, use of Internet services by citizens, integration of digital technologies by enterprises and digital public services. The conducted analysis made it possible to divide countries with similar characteristics into 2 clusters. Thus, the first group included 22 countries with high rates of digital development of the economy and society, including Denmark, the USA, Germany, Japan, South Korea, the Netherlands and Sweden. 13 of the 22 countries are the EU member states. All the countries of the first cluster are developed

countries that have a significant share of high-tech services in their economy as well as investments in high-tech products.

The level of the Digital Economy Index in EU countries for 2022 is shown in Figure 2.6. The DESI 2022 results show that while most EU Member States are making progress in digital transformation, business adoption of key digital technologies, such as artificial intelligence and big data, remains low even among EU leaders. Insufficient digital skills hinder future growth prospects, widen the digital divide and increase the risks of digital exclusion, the abandonment of all additional services, individual ones, going online. Efforts need to be stepped up to ensure the full deployment of the communications infrastructure (including 5G) necessary for innovative services and applications.

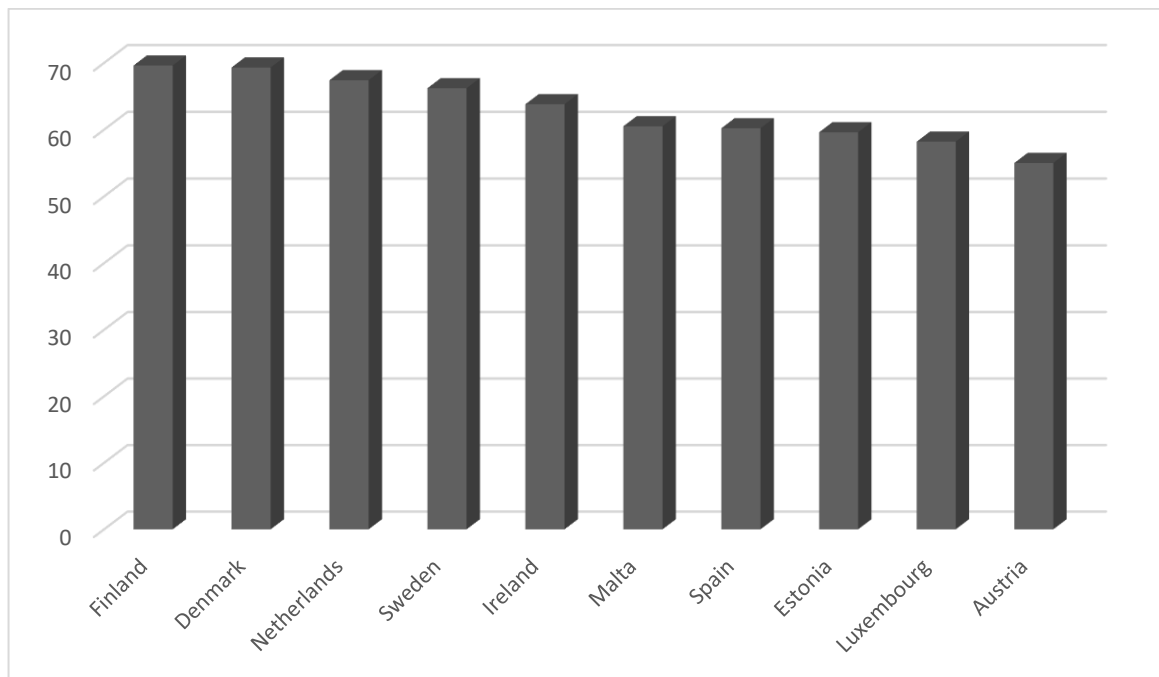


Fig. 2.6. Digital Economy and Society Index in EU countries for 2022

Source: structured by the author based on [24]

Sweden and Finland have the most digitized small and medium-sized enterprises (SMEs) (86% and 82% have a basic level of digital intensity respectively), while Romania and Bulgaria have the lowest rates of digitization of SMEs. To achieve the Digital Decade

target by 2030, at least 90% of SMEs in the EU must have a basic level of digital intensity. Businesses are becoming more digital, but the use of advanced digital technologies remains low. According to the “Pathways to a Digital Decade” proposal, at least 75% of enterprises should be switching to artificial intelligence, cloud technologies and big data by 2030.

By 2019, the Chartered Institute of Procurement & Supply found in a survey of 700 managers, representing over 20 industries and 55 countries, that over 90% of the businesses represented had adopted at least one new form of information technology, and 90% stated that their digitalisation strategies aimed to secure decreased operational costs and increased efficiency.[25] In a 2021 survey, 55% of European companies stated the COVID-19 pandemic has increased the demand for digital technology, and 46% of companies reported that they have grown more digital. Half of these companies anticipate an increase in the usage of digital technologies in the future, with a greater proportion being companies that have previously used digital technology. A lack of digital infrastructure was viewed as a key barrier to investment by 16% of EU businesses, compared to 5% in the US. In a survey conducted in 2021, 89% of African banks polled claimed that the pandemic had hastened the digital transformation of their internal operations.[26] In 2022, 53% of businesses in the EU reported taking action or making investments in becoming more digital. 71% of companies in the US reported using at least one advanced digital technology, similar to the average usage of 69% across EU organizations.[27]

The GII provides a comprehensive assessment of innovation capabilities and outcomes across a wide range of economies, using indicators such as R&D expenditure, human capital, infrastructure, market sophistication, and knowledge and technology outputs.

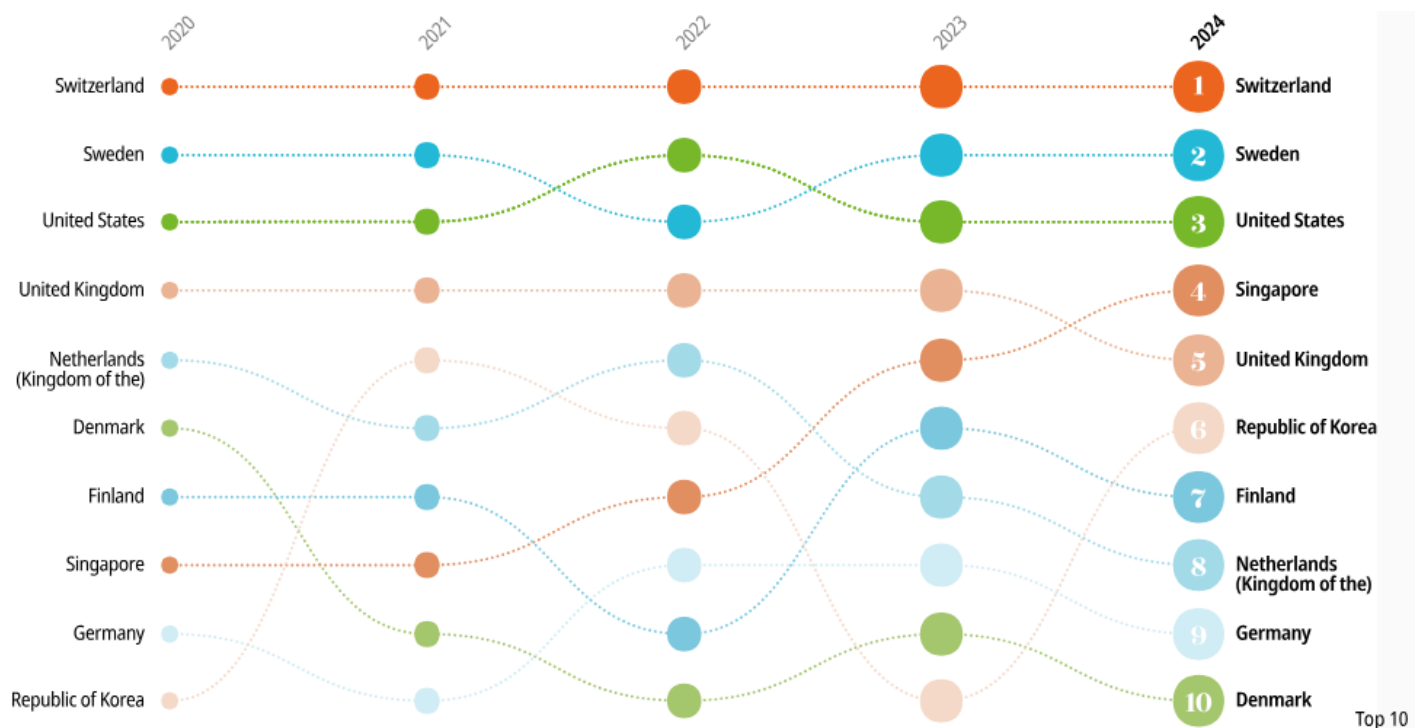


Fig. 2.7. The GII dynamo: The top 10 innovators, 2020–2024

Source: [28]

The following figure presents the top 10 countries that have remained at the forefront of global innovation from 2020 to 2024, highlighting the stability of their innovation systems and their pivotal role in shaping future economic and technological trends.

The World Digital Competitiveness Ranking 2024[29] shows that countries like Singapore, Switzerland, and Denmark lead the world by effectively adopting and integrating new technologies. Their success heavily depends on strong digital infrastructure, high investments in education, research, and innovation, and adaptive governance models. This year's index highlights the growing importance of digital equity, affordable housing, and environmental sustainability. It reveals increasing resident concerns about security, road congestion, and trust in governance. Cities like Zurich and Oslo, which prioritize these aspects, not only maintain their high rankings but also set benchmarks for others to follow. Digitalization enhances their business agility, innovation

output, and public service efficiency, positioning them as frontrunners in the global economy. These countries illustrate that future economic strength is closely tied to how well digital technologies are embraced.

- 1) Singapore tops the ranking due to strong investments in ICT infrastructure, support for innovation ecosystems, and widespread digital literacy. Its Smart Nation program integrates technology into everyday life and public services, boosting business agility and innovation readiness.
- 2) Switzerland maintains leadership through world-class education, significant research and development (R&D) funding, and a highly efficient regulatory framework that promotes technology adoption. Switzerland's digital competitiveness is strengthened by its adaptability and innovation-driven economy.
- 3) Denmark excels in e-government, renewable technologies, and digitized public services. Its emphasis on integrating digital tools into governance and business processes makes it a global leader in technology use and sustainable innovation.

In all three cases, digitalization acts as a catalyst — enhancing productivity, facilitating new business models, ensuring faster adaptation to market changes, and improving national resilience. In contrast, countries lagging in digital infrastructure, human capital development, and innovation policies face challenges in maintaining competitiveness. Thus, the global economic landscape increasingly depends on the ability of countries to embrace digital transformation comprehensively: from public administration and education to corporate innovation and societal digital skills. AI continues to drive innovations that improve safety, efficiency, and inclusivity, reflecting the evolving role of digitalization in shaping governance, mobility, and overall quality of life in cities around the world. Digital transformation technologies have a significant impact on improving financial performance. For example, return on assets (ROA) and return on equity (ROE) tend to increase after the implementation of digital technologies. The study “Dual Perspectives on Financial Performance: Analyzing the Impact of Digital Transformation

and COVID-19 on European Listed Companies”[32] conducted in 2023 analyzed 2,179 European companies whose shares were listed on the stock exchange from 2015 to 2021. The study confirmed the claim that digital transformation had a positive impact on financial performance, as measured by return on assets and return on equity (ROA and ROE). A 1% increase in digital capabilities led to an improvement in financial performance by almost 58% according to a fixed-effect regression model.

Smart companies are combining human teams with digital tools. The global digital transformation market size was valued at USD 809.12 billion and is accelerating due to the strategic adoption of advanced technologies across major industries. As organizations worldwide pursue higher operational efficiency, customer engagement, and resilience, digital technologies are becoming core components of business models. According to recent analyses, the key drivers behind this transformation include the need for remote collaboration tools, data-driven decision-making, and agile infrastructure. Research by Grand View Research (2024)[43] projects that the digital transformation market will surpass USD 1.3 trillion by 2025, with a compound annual growth rate exceeding 27.6% through 2030. These dynamics reflect not only a shift in operational tools but a foundational change in how value is created, delivered, and sustained within enterprises.

The implementation of digital platforms not only enhances internal processes but also opens up new economic opportunities through scalable and modular systems. Companies adopting cloud services, for example, benefit from reduced IT costs, increased data security, and real-time collaboration, which enables faster response to market demands. Similarly, AI-powered automation supports cost optimization, predictive maintenance, and enhanced customer personalization—capabilities that were previously unattainable at scale. Digital maturity correlates strongly with financial performance. Corporations that strategically integrate digital transformation show measurable gains in profitability and market capitalization. (Fig.2.8.)

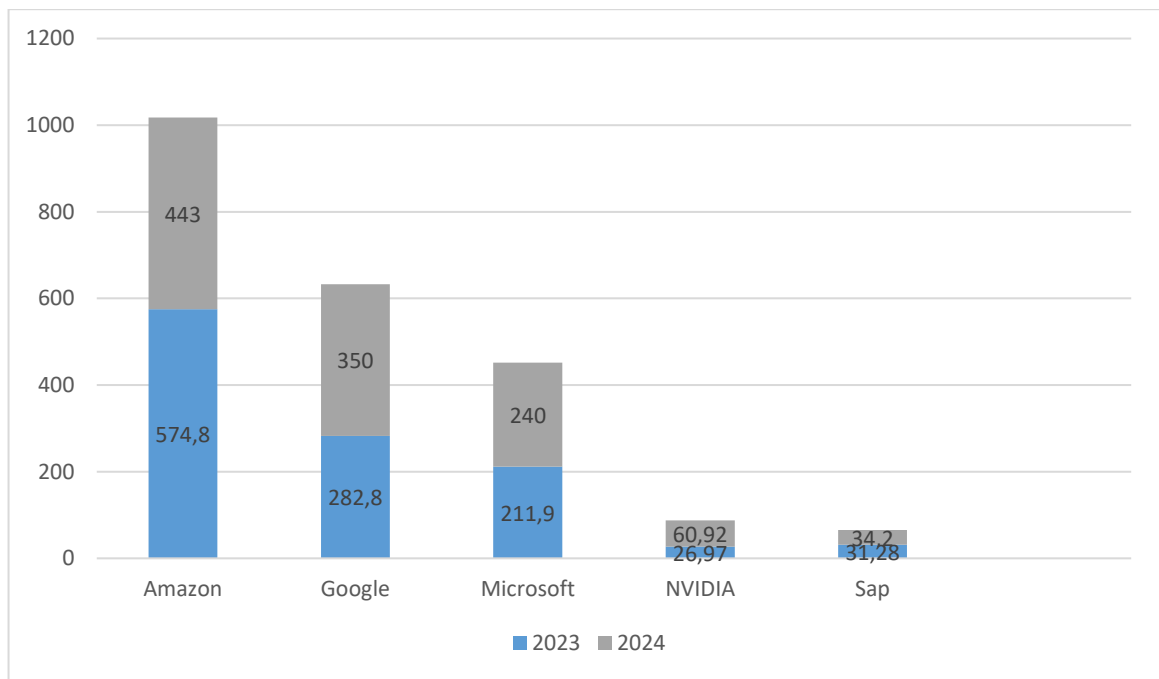


Fig.2.8. Revenue growth rate of giant companies for 2023-2024

Source:[44]

Amazon is a global benchmark in digital logistics and cloud innovation. Its success stems largely from Amazon Web Services (AWS)—the world’s most widely adopted cloud platform, offering over 200 fully featured services. Additionally, Amazon has revolutionized supply chains through the automation of warehouse operations, robotics and predictive delivery algorithms based on machine learning. The productivity ecosystem—Microsoft 365—has evolved into a digital workplace backbone, merging traditional office tools with cloud collaboration and AI enhancements. Microsoft's deep investment in AI,, places it at the frontier of generative technologies and intelligent automation, directly supporting enterprise-scale digital transformation across industries. Alphabet (Google) has built a digital empire rooted in data. Google Search, Maps, and Ads operate within an ecosystem of integrated services, all strengthened by continuous real-time data optimization and cloud processing power.

NVIDIA plays a fundamental role in the digital infrastructure supporting AI and simulation. NVIDIA's GPUs power the data centers that enable generative AI, while its sovereign AI infrastructure partnerships with national governments and cloud providers reflect its critical position in geopolitical digital strategy. In 2024, NVIDIA doubled its revenue largely due to explosive demand for AI-capable hardware. As a leader in enterprise software, SAP enables digital transformation for corporations through integrated resource planning (ERP) and cloud analytics, the company allows real-time data processing and decision-making across finance.

It is also important to note that the impact of digital transformation is the difference between companies with low and high financial performance. Companies that are in a crisis or unstable financial situation can significantly improve their performance through digital transformation. By automating manual processes, reducing operational inefficiencies, and introducing data-driven decision-making, such companies often achieve measurable improvements in productivity, cost control, and market responsiveness. Digital transformation enables struggling firms to modernize legacy systems and adopt agile operational models. In contrast, companies that delay or underinvest in digital transformation often face declining competitiveness, inability to adapt to consumer expectations, and increased operational risk. Thus, digital transformation is not only a driver of innovation but also a critical tool for financial stabilization and strategic recovery.

2.2. Digitalization of Ukraine and future plans, trends and tendencies

Modern trends of globalization and economic transformation make it essential for countries to pursue progressive and long-term economic development strategies that align with ongoing digital shifts. Ukraine is no exception to this global movement. Modern globalization trends and economic transformations necessitate the need to ensure progressive long-term development of the economies of the world in the context of digital transformational shifts. The corresponding trend has not bypassed Ukraine. It is also important to note the importance of developing and implementing digital transformations in the country. The level of digital skills of Ukrainians is on the rise. According to a study by the Ministry of Digital Transformation of Ukraine[33], 93% of the country's adult population aged 18 to 70 have basic digital skills. According to the results of the 2023 study, the share of the adult population with digital skills below the general level increased by 12.6% compared to 2019, reaching 40.4%. At the same time, the percentage of people with no digital skills has halved compared to 2019 and is currently 7.2%. To analyze the investment attractiveness of the national economy in the context of digital transformation, let's consider the statistics in Figure 2.8. From the marked figure, it can be seen that the dynamics of the investment attractiveness index of the Ukrainian economy in the context of digital transformation in the second half of 2024 had a positive decrease (2.48 points) in comparison with the first half of this year. The trend line marked in the figure has positive dynamics, which will have significant characteristics for the formation of strategic priorities for ensuring the effective development of the Ukrainian economy in the context of digital transformation.

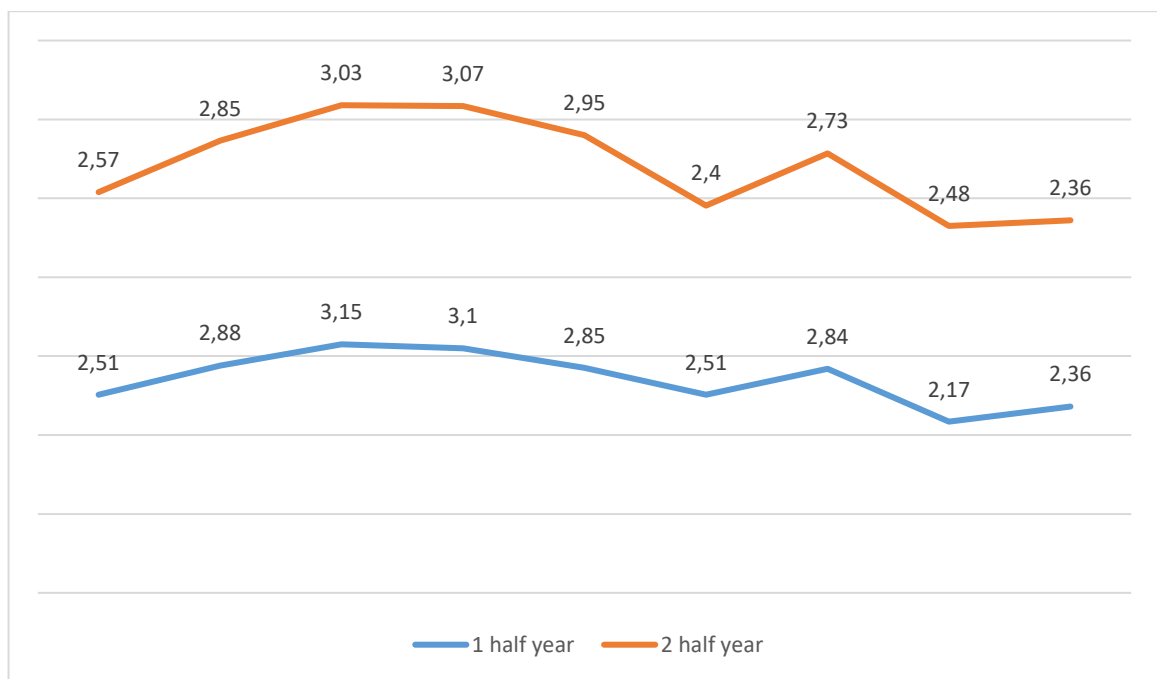


Fig.2.9. Dynamics of the investment attractiveness index of the Ukrainian economy in the context of digital transformation in the period 2015 – 2025

Source[34]

One of the directions of public administration reform is the introduction of e-governance. In the course of the gradual implementation of the stages of public administration reform, as of today, the following are already functioning:

1) digital transformation of administrative services, in accordance with which more than 120 types of services are provided electronically and are available on the official websites of entities providing such services;

2) a single state web portal for electronic services called the Diia Portal has been formed and put into operation, thanks to which every citizen of Ukraine has the right to receive electronic services and information about himself from state information electronic resources;

3) the Diia mobile application, thanks to which every citizen of Ukraine has access to digital documents.

The advantages of implementing the digitalization of administrative services will significantly reduce the level of bureaucracy and establish relations between various executive bodies of all levels, as well as improve the procedure for providing administrative services. In September 2019, the Ministry of Digital Information was created in Ukraine. Among its tasks was the development of the “state in a smartphone” project. It was officially launched in 2020 under the name Diya. It combines a mobile application and a public services portal.

Right on your smartphone, you can now receive a marriage certificate, documents for a newborn child, subsidies, pensions, open a sole proprietorship, etc. In addition, Diya stores your passport, Covid certificate, driver’s license, and international passport. Through Diya, internally displaced persons receive assistance, you can donate to the Armed Forces of Ukraine, watch TV channels, and register damaged property for compensation for losses. No other European country has a similar application.

Ukraine also boasts advanced systems such as Prozorro for public procurement and Prozorro. Sale for state property auctions. These systems have remained fully operational even during wartime, thanks to cloud infrastructure ensuring resilience and data security. With the beginning of a full-scale war, these systems did not stop for a moment. Because they are located in private GigaCloud clouds. The cloud provided them with fault tolerance and reliable storage of critical data. Digital economy (Internet economy, new economy, web economy) is a new development model for Ukraine, based on digital computer technologies. New digital technologies allow you to create huge amounts of information and distribute it among an almost infinite number of people - quickly, efficiently and cheaply. As a result, the process of digitization has covered all levels of modern society: public administration, economic management, business and the everyday life of each of us.

Digitalization has significantly facilitated everyday life and allows you to quickly process any information, and helps speed up a person's work. Currently, there are more than 120 online services in Ukraine, which are posted on the website guide.diia.gov.ua, or on

the public services portal igov.org.ua. You can apply for the status of an internally displaced person online by simply submitting documents via the Internet; issue certificates and bank cards, change the name or surname in the passport, get a pension certificate and even file for divorce, etc.

By combining different data, you can get fundamentally new services. These services not only simplify life, but also reduce costs and increase labor productivity. Ukraine is the first country in the world where digital passports are used on a par with paper ones. Ukraine legalized digital passports in the State Duma and from August 23, 2021 they are complete analogues of paper 197 and plastic passports.

According to the Coursera Global Skill Report 2022 on the main trends in the development of specialist skills in the world, Ukraine entered the top ten best in technical qualifications[35]. In 2022, Ukraine took 8th place in the IT skills rating and was recognized as an advanced country. Assessing the level of skills in all areas and directions, Ukraine was ranked among the progressive countries of the world and ranked 21st in Europe. According to the Ukraine IT Report 2023, Ukraine is considered one of the leaders in Eastern Europe in terms of the number of IT workers.

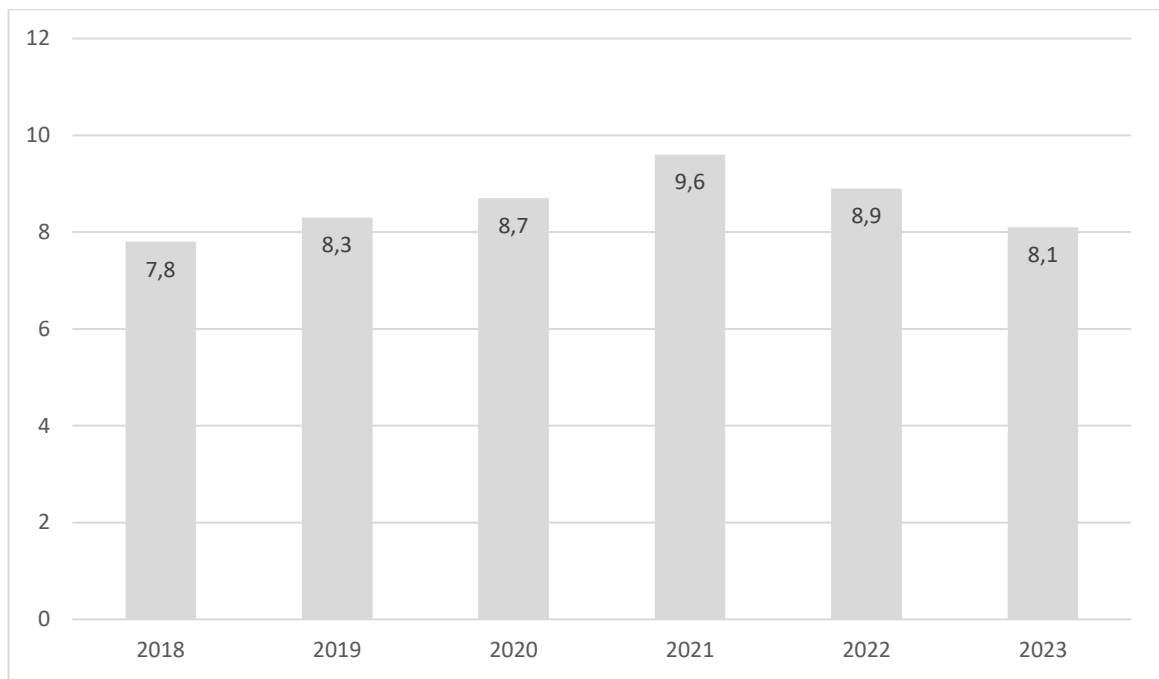


Fig 2.10. Number of operating legal entities providing IT services

Source[36]

According to the joint study of Forbes Ukraine and KPMG in Ukraine[37], despite the full-scale invasion, 60% of Ukrainian companies have accelerated the process of digitalization. Although many Ukrainian companies invest from 1% to 5% of their annual income in digitalization, companies in the food industry, telecommunications and financial sectors allocate more than 20% of annual income in digitalization. Digitalization is firmly established in the long-term strategies of Ukrainian companies: 99% of respondents noted it as part of the strategic vision, and 96% actively monitor the effectiveness of the use of already implemented digital technologies. The most important results of digitalization for business are indicators of reducing operating costs (76%) and attracting/retaining customers (68%).

The use of advanced technologies, such as artificial intelligence and machine learning, reveals interesting patterns in staff involvement in digitalization processes: companies that use these technologies are less likely to have high staff involvement (4%), but at the same time are more likely to create specialized technical teams (69%). In contrast,

in companies that do not use such technologies, staff involvement remains high (35%), but the lack of specialized teams can create certain challenges. The data shows that companies that rely on complex technical solutions focus on forming narrowly focused expert groups that ensure the implementation of digital transformation at the strategic level.

Digital tools and technologies that are officially implemented by domestic business entities include the inclusion of enterprise resource planning (ERP), innovative solutions for business process automation, analytical platforms for data, digital marketing, digital transformation of business models, digitalization of business processes, tools for human resource management. Digitalization and digitalization through optimization of work processes, improvement of data analysis, increase the efficiency of management decisions and overall efficiency of activities:

- Digital tools for analysis and forecasting.

- Analytical platforms (e.g., Power BI, Tableau) allow you to collect and analyze big data to make informed decisions. They help identify trends, risks, and opportunities, allowing the enterprise to quickly respond to changes in the economic environment.

- Forecasting systems (e.g., SAS, IBM SPSS) provide historical data and machine learning to predict future trends, which reduces uncertainty in planning.

Since the start of the full-scale war in Ukraine, 63% of companies have accelerated the pace of digitalization and increased their focus on technology, while 31% have adapted their strategies to make them more flexible. Service companies continue to pay more attention to technology than manufacturing companies.

The majority (95%) have implemented initiatives aimed at optimizing and saving resources, but only half use advanced technologies for decision-making and innovation, and up to 40% apply them to solve logistical problems. Interestingly, for 10% of companies, the war did not affect their planned technological implementations. At the same time, all

medium-sized companies, regardless of industry, implemented technological initiatives in response to the challenges of the war.

In order to improve the investment climate in Ukraine, it is necessary to carry out a number of measures, in particular: to stop corruption and increase the transparency of decision-making by the judiciary; focus on human potential development to ensure future economic growth; mitigate the conditions for granting loans for investment projects; simplify the registration procedures of business entities; carry out risk insurance of foreign investors; provide tax incentives; promote investment infrastructure development; improve the legislative framework; stabilize the economic situation in the country; conduct a clear state policy aimed at improving the country investment climate; enhance the image of Ukraine on the world stage; stabilize the political situation, especially in relation to the settlement of a military conflict, etc.[38]

Another example of Ukraine's development as a high-tech country is the "Dream and Achieve" educational program for female entrepreneurs who have suffered as a result of the full-scale Russian invasion. Participants will gain the necessary knowledge and develop skills to create or develop their own online business, mentoring support, and a financial support of \$1,000 upon completion of the training.

The program offers comprehensive training lasting three months, which includes 13 intensive thematic online modules, such as digital marketing, business strategy, and the implementation of sustainable, socially responsible business models. Improvement of the investment climate is an important task, the solution of which will allow increasing the pace of economic development of the country. The advantages that Ukraine has can attract foreign investors if they solve a number of problems that hinder the attraction of foreign funds for economic development.

To improve digital literacy and digitalization, Ukraine must develop not only in the sphere of market economy but also in education, by integrating digital tools and promoting

STEM disciplines; in public administration, by advancing e-governance and accessible online services; in cybersecurity, by protecting infrastructure and teaching safe internet practices; in social inclusion, by ensuring digital access for all citizens; and in innovative entrepreneurship, by supporting startups, tech hubs, and research in digital fields.

In the Figure 2.11. we see how it can be improved:

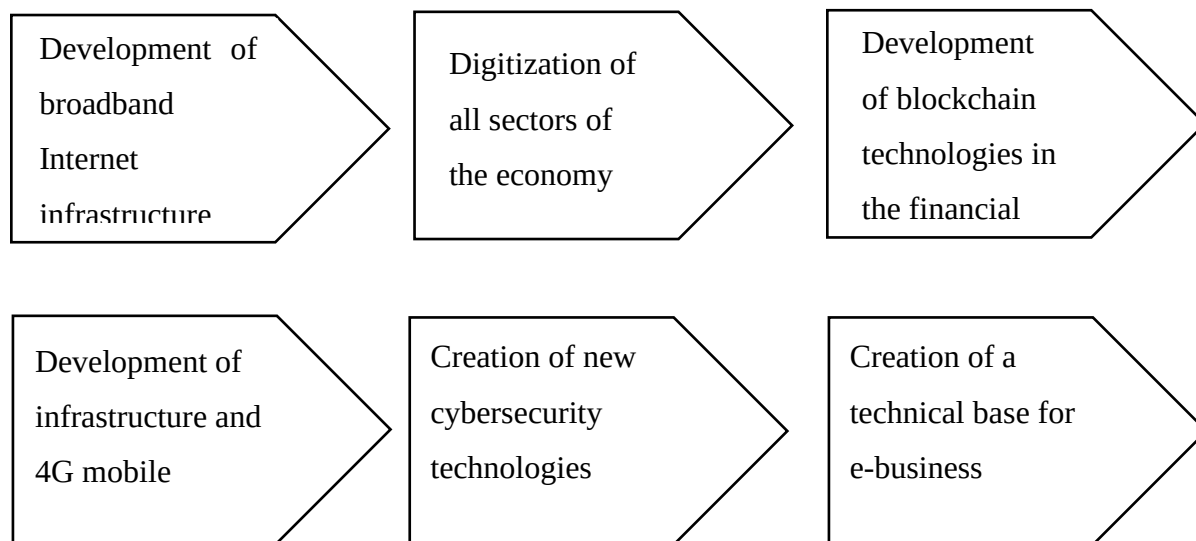


Fig. 2.11. The areas for improving the level of digitalization in Ukraine

Sourse: make by the autor

The Ministry of Education and Science of Ukraine cannot remain aloof from the problems and therefore has created a strategy for the further development of education, namely, it has developed a draft Concept of Digital Transformation of Education and Science for the period until 2026[39], which provides for a comprehensive digital transformation of this sphere. This concept also corresponds to the main tasks of the implementation by executive authorities of the principles of the state policy of digital development and the main directions and tasks of digital transformation for the period until 2023, which were approved by the order of the Rada of Ukraine dated February 17, 2021.

The main tasks set will be:

- development of information and digital literacy of teaching staff;

- providing participants in the educational process with access to high-quality digital resources;
- final approval of the Concept of Digital Transformation of Education and Science of Ukraine;
- complete update of the Unified State Electronic Database on Education;
- launch of an online resource for interaction between participants in the innovation process (“Science and Business”);
- implementation of the SELFIE project, which allows educational institutions to assess their level of digital readiness;
- development of the educational platform “All-Ukrainian School Online”.

For the successful implementation of the plan, the following steps will need to be followed:

- ✓ ensure the availability of educational materials in real time for simplified access to new knowledge;
- ✓ combine knowledge from different fields for better mastery;
- ✓ constantly carry out rapid adaptation of knowledge, ensure its practical application immediately during training, remaining simply accumulation has long lost its relevance.

In summary, Ukraine's path toward digital transformation is multifaceted, encompassing governance, economy, education, and social inclusion. Despite external shocks, particularly the ongoing war, Ukraine continues to demonstrate resilience and innovation. Continued investment in digital infrastructure, human capital, and transparent governance will be key to strengthening its position in the global digital economy.

2.3. Prospects and plans for the development of digitalization in the international market

Digitalization requires predictable and rapid adaptation, which enhances the positive effects of digitalization, requires significant investments and radical changes in structures and processes. The international competitiveness of individual economies will crucially depend on how quickly digital technologies are used in production processes, and whether the country has the necessary resources for this transformation. The available resources largely depend on the achieved level of economic development. As a rule, this is measured by the level of real gross domestic product (GDP) per capital.

The European Union actively supports and develops the digital economy as a basis for the development of all sectors of the economy. The EU's economic policy aims to promote the development of a single digital market and the prospective creation of the EU Digital Union. The creation of a single digital market is one of the main prospects and challenges of our time. Digitalization has created a world without borders and its implementation requires a new form of governance based on its specific properties. This process requires addressing a number of practical and political issues in the economic and trade relations of the international community. Research by Carol Corrado and co-authors shows that in the US, investments in intangible assets (intellectual property, software, organizational competencies) account for about 50% of total capital, while in EU countries is only 23.8%.[40] In response to the challenges associated with the need for digital and green transformation, the European Union has introduced the NextGenerationEU program[41] - the largest stimulus package in the history of the EU with a total budget of over 750 billion euros. The main objective of the program is to support the economic recovery after the COVID-19 pandemic and ensure sustainable, digital and environmentally friendly development of member states.

The key instrument of the program is the Recovery and Resilience Facility, which has been allocated 672.5 billion euros. It focuses on financing reforms and investments in the areas of digital transformation, climate neutrality, innovative economy and social cohesion. According to the official website of the European Commission, the participating countries of the program must invest at least 37% of the funds received in the "green transition" and 20% in digital transformation.

Each EU country has developed a National Recovery and Resilience Plan, which identifies investment areas. For example, Italy will receive the largest share of €194.4 billion, which will be used to modernise its administrative system, reform its judiciary, develop infrastructure and digitalise. Spain will focus on labour reform and the digital transition. All these efforts are aimed at creating a more competitive, technological and green European economy. NextGenerationEU is thus not only a recovery tool, but also a long-term development strategy for the EU, which will contribute to improving the well-being of its citizens, strengthening its international competitiveness and the transition to a new economic model. Individual country examples demonstrate the adaptation of investments to national needs and structural challenges.

Italy is a prime example of the country that has achieved the greatest success in financing — over 122 billion euros. It is directing spending on public administration reform, digitalization of logistics systems, development of agro-solar technologies and ecological modernization of national parks. This approach ensures both environmental and technological sustainability, while increasing the country's investment attractiveness.

Portugal, in turn, is focusing efforts on overcoming energy poverty, developing green hydrogen technologies, and decarbonizing public transport. At the same time, the renovation of medical institutions is being completed through the purchase of modern equipment that works on the complex interaction of environmental and social goals. Latvia is focusing on reducing the digital divide, investing 11 million euros in providing educational institutions with laptops. This not only improves access to education, but also

promotes inclusive digital development in the region. Slovenia implements socially oriented projects, in particular the construction of residential complexes for the elderly, which promotes intergenerational integration and improves the living conditions of the older generation.

Horizon Europe[42] is the EU's key funding programme for research and innovation. Following the Multiannual Financial Framework Midterm Review (MTR) decision, the indicative funding amount for Horizon Europe for the period 2021-2027 is EUR 93.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth.

The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate. Key priorities include:

- Green transition and support for research on climate change, biodiversity conservation and sustainable development.
- Digital transformation, development of critical digital technologies, including artificial intelligence and quantum computing.
- A resilient and inclusive Europe - strengthening democratic institutions, social cohesion and economic resilience.

In 2025, the Creative Europe programme is actively promoting a long-term strategy for the development of culture in the EU, focused on digital transformation, environmentally sustainable culture, social inclusion and expanding international cooperation. It is planned to actively involve organizations in joint projects aimed at

strengthening the role of culture in shaping European identity and strengthening democracy. Significant attention is also paid to supporting Ukraine. Readiness 2030 the initiative, with a budget of up to €800 billion, aims to strengthen the EU's defence capabilities in response to geopolitical challenges. To be able to live in peace, we need significantly higher investments in European defence to ensure the security of all EU citizens today and in the future.

This is the key message of the White Paper on European Defence, presented on 19 March by the EU High Representative for Foreign Affairs and Security Policy Kaia Kallas and the European Commissioner for Defence and Space Andrius Kubilius. The White Paper [45] contains an action plan and aims to create a more capable, fully prepared European defence by 2030. Main points of the White Paper for European Defense EU Member States are responsible for Defense. They need to obtain the defense capabilities they need for Europe to defend itself and to deter against threats. The EU can help Member States reach that goal, through aggregating demand for and encouraging the collective procurement of defense equipment. Seven priority areas have been identified in line with the decision taken by EU Member States at the European Council of March 6:

1. Air and missile defense
2. Artillery systems
3. Ammunition and missiles
4. Drones and anti-drones systems
5. Military mobility
6. AI, quantum, cyber and electronic warfare
7. Strategic enablers and critical infrastructure protection including strategic airlift, air-to-air refueling, maritime domain awareness, and protection of space assets.

The global economy has benefited from digital-driven growth, with industries that produce, process, and sell data-driven services growing much faster than traditional ones.

In addition, companies are now not only investing their profits in technologies such as artificial intelligence, but also acquiring successful digital startups to expand their portfolios.

Given the potential knock-on effects of digitalization on the labor market, the growth of technology-intensive businesses has already led to a demand for digital professionals around the world. However, there are concerns that rapid automation could reduce the number of workers needed, meaning that middle-class professionals currently employed primarily in finance, law, and accounting could become unemployed.

Globalisation processes contribute to the fact that digitalisation facilitates access to international markets, allowing businesses from any country to compete on a global scale. In turn, businesses that adapt quickly to new technologies and create innovative products gain a competitive advantage. The EU's Digital Single Market (DSM) aims to create a single digital space where businesses and consumers can interact seamlessly. The main elements of the DSM include:

- removing barriers to online trade, namely simplifying procedures for cross-border trade and ensuring equal access to all goods and services;
- modernising copyright rules by adapting legislation for the digital age, ensuring a fair balance between authors' rights and access to content;
- improving cybersecurity by ensuring a high level of data protection and cybersecurity to protect consumers and businesses;
- directing investments into digital infrastructure that ensures the development of high-speed internet networks and innovative technologies such as 5G.

The European Union (EU) Digital Single Market, along with new opportunities, creates challenges for businesses. To remain competitive in the context of digitalization and globalization, businesses must adapt their strategies and processes. Let's consider what

steps need to be taken to ensure the competitiveness of businesses in the EU Digital Single Market.

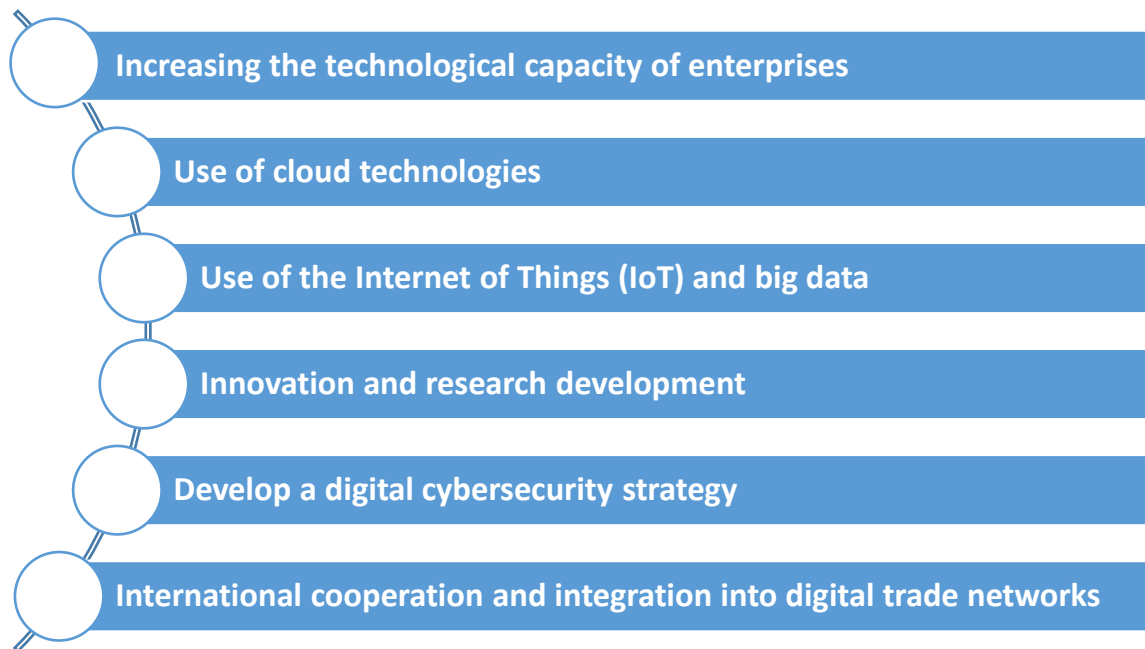


Figure 2.1. Steps to improve Europeanian digitalisation on the markets

Source: make by the autor

Increasing the technological capacity of enterprises is related to the implementation of modern IT systems. Modern information technologies are key to improving the efficiency of business processes. The use of modern corporate platforms — such as ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) — is the basis for increasing competitiveness on international electronic trading platforms. ERP systems provide centralized management of all business processes — from logistics to finance — which is especially important for enterprises integrating into the EU's digital trading ecosystems. CRM systems, in turn, improve the quality of customer service, allow for personalized communication and create flexible digital channels of interaction. Thanks

to real-time analytics, these systems contribute to making informed management decisions and increase the efficiency of work on digital commodity markets.

Cloud technologies provide flexibility, scalability and reduced IT infrastructure costs. They allow businesses to store and process data in the cloud, which provides access to information from anywhere and at any time. Using cloud services reduces the need for investment in their own IT infrastructure. Cloud solutions are easily scalable according to business needs. Cloud platforms are constantly updated, allowing businesses to use the latest technologies. The EU is actively developing the GAIA-X project, a European federated cloud infrastructure aimed at creating a secure, transparent and interoperable environment for storing and transferring data between companies and organized markets.

IoT and big data analysis allow enterprises to obtain more accurate and timely data for decision-making. This can include monitoring production processes, optimizing logistics chains, and forecasting demand. IoT allows for real-time monitoring of equipment and processes. Collecting data from IoT devices allows for optimizing processes and reducing costs. Using IoT helps improve customer service, and in products allows for offering new services and improving customer interaction. In turn, big data analysis helps predict demand changes and optimize production, and allows you to identify bottlenecks in processes and find ways to eliminate them. Using big data to analyze customer behavior allows you to create more effective marketing campaigns.

Innovation and research development is related to investment in research and development (R&D). Innovation is a key factor of competitiveness. Enterprises should actively invest in research and development of new products and services. This may include cooperation with research institutions, universities and startups. Such cooperation ensures the creation of new products: Investment in R&D helps to create innovative products that meet market needs. The development of new technologies and methods allows to increase production efficiency and reduce costs. Enterprises that are actively engaged in R&D gain competitive advantages in the market. The creation of internal innovation centers allows

enterprises to focus resources on the development of new technologies and products. Such centers can be a place for experiments and testing new ideas before their introduction into mass production. Innovation centers allow you to focus your efforts on developing new solutions.: Having an experimental base for testing new ideas reduces risks and allows you to implement innovations faster. Innovation centers facilitate cooperation with other companies, startups and research institutions. Digitalization opens up opportunities for the implementation of new business models, such as the sharing economy or marketplaces. Companies must be ready to adapt their strategies to new market conditions. New business models allow companies to diversify their sources of income. Sharing resources allows you to reduce costs and increase business efficiency.

As digitalization increases, so do the threats associated with cyber risks. To operate smoothly in international commodity markets, it is necessary to develop a comprehensive system for protecting digital assets. This includes implementing cyber security technologies, antivirus systems, backup mechanisms, and constant monitoring of cyber threats. Businesses must ensure compliance with European standards, including GDPR, to maintain the trust of customers and partners in digital trade channels. In response to the growth of digital risks, the EU adopted the European Cybersecurity Strategy (2020) and created the European Cybersecurity Competence Center. As part of this strategy, businesses integrating into digital organized markets can access certified cybersecurity solutions, common data protection standards, and recommendations for compliance with NIS2 and GDPR standards.

International cooperation and integration into digital trade networks. Participation in cross-border digital initiatives, strategic alliances and international projects allows enterprises to gain access to the latest technologies, infrastructure and financing. This increases competitiveness, accelerates adaptation to global standards and opens up new markets for digital products and services. Entering international markets increases brand awareness and its reputation. E-commerce allows enterprises to significantly expand the geography of their

sales. The introduction of electronic platforms for selling goods and services, such as their own online stores or marketplaces, is an important step for business expansion. E-commerce reduces the costs of maintaining physical stores and personnel. Online shopping becomes more convenient and faster for customers. Cooperation with international companies helps enterprises to gain access to new technologies, resources and markets. This may include strategic alliances, joint ventures and partnerships. Partnering with international companies allows for faster access to new markets. The EU is actively promoting digital trade chapters in free trade agreements, in particular in cooperation with Japan, Singapore, Canada and Chile. Through the new Global Gateway initiative, the EU is investing up to €300 billion in digital infrastructure that allows partner countries (including Ukraine) to be integrated into a single digital ecosystem covering logistics, finance and data exchange.

The advancement of digitalization in the international market signifies a pivotal transformation in the mechanisms of global trade. By aligning national strategies with global digital trends, countries can increase their competitiveness, strengthen economic resilience, and create a more accessible and integrated global market. Digitalization is no longer an option—it is an imperative for long-term prosperity and innovation in international trade. Looking forward, the development prospects for digitalization remain highly favorable. Countries and enterprises that invest in digital competencies and cybersecurity, while fostering innovation-friendly ecosystems, are expected to play a leading role in shaping the future architecture of global commerce.

Conclusions

In the process of studying the topic of digitalization of organized commodity markets in international trade, it was established that digital transformation is not only a technological trend but also a fundamental driver of structural changes in the global economy. From the early automation of accounting processes to the contemporary application of artificial intelligence, big data analytics, and blockchain, digital technologies have radically reshaped both internal business operations and the mechanisms of international trade. However, despite the advantages, the study has highlighted critical challenges that must be addressed to fully leverage digitalization. Key issues include the growing threat of cyberattacks, technological disparities between developed and developing economies, regulatory gaps, and the complexity of integrating new digital infrastructures into existing market structures. The example of Ukraine, which are actively pursuing digital transformation strategies, face additional barriers such as limited IT funding and a shortage of qualified personnel, underscoring the need for targeted investments and international cooperation. In modern conditions, it is necessary to implement innovative approaches to business and develop new values of goods and services using digital channels. Digitalization contributes to the development of new ideas for conducting entrepreneurial activities, increasing competitiveness, creativity and value of goods and services. Dynamic changes in the external environment force us to adapt to digital innovations and satisfy the growing demand of digitalized consumers.

The first section of the research revealed the conceptual foundations of digitalization and its essential role in enhancing transparency, speed, security, and efficiency in trade. It was shown that digitalization leads to reduced transaction costs, broader market access, and greater competitiveness for trade participants. However, these benefits are accompanied by several challenges, including growing cybersecurity threats, technological disparities among countries, and the urgent need for updated regulatory frameworks. The second section explored international experiences in digital transformation. Leading economies such as the

United States, the European Union, and advanced digital nations demonstrate successful models for integrating digital solutions into trade through targeted public policy, strategic investment, and the development of supportive regulatory environments. Regarding Ukraine, the country is steadily advancing toward global digital integration by implementing national digital strategies, launching state platforms, and participating in international digital initiatives. Despite progress, significant barriers remain, including limited IT funding, a shortage of skilled professionals, and the need for alignment with European digital norms and standards. Furthermore, digital transformation has been shown to directly influence the financial performance of companies by improving operational efficiency and competitiveness. Empirical studies demonstrate that even modest increases in digital capabilities can significantly enhance key financial metrics such as return on assets and return on equity. This underlines the necessity for both private enterprises and public institutions to prioritize investments in digital infrastructure and human capital development to fully leverage the potential of digital transformation.

Looking ahead, the development prospects of digitalization in organized commodity markets are closely tied to enhanced international cooperation, the establishment of interoperable digital platforms, the wider use of smart contracts, and investment in robust digital infrastructure. These advances must be supported by comprehensive strategies that ensure innovation, security, and inclusiveness in global trade systems.

In conclusion, digitalization is not merely a technological enhancement but a strategic imperative for the modernization of international trade and the sustainability of commodity markets. It stands as a cornerstone of sustainable economic growth and international competitiveness in the 21st century. It fosters efficiency, transparency, and resilience, while also creating opportunities for innovation and equitable growth. However, to fully realize its potential, a coordinated and multi-level approach is required—engaging governments, businesses, and international institutions alike. The key to success lies in an integrated approach that balances innovation with risk management, ensuring that

technological advancements translate into tangible economic and social benefits across all levels of market participation. The countries and organizations that prioritize digital transformation today will be the ones shaping the future of global trade and economic competitiveness.

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APPENDIXES

The concept of smart cities represents a global trend aimed at enhancing the intelligence and sustainability of urban environments through the gradual integration of various digital technologies. Around the world, numerous cities are undergoing transformation, adopting innovative solutions to improve infrastructure, services, and quality of life. A truly smart city is characterized by its ability to attract and support businesses, foster innovation and creativity, and provide its residents with ample opportunities for personal and professional growth.

Top 10 Smart Cities in the World in 2025[30]:

Zurich, Switzerland

Zurich is the undisputed leader among smart cities. Its efficient public transport, low-emission zones, and smart recycling systems showcase how digital innovation can coexist with environmental responsibility. The city uses data-driven solutions to manage energy, traffic, and public safety. Zurich's commitment to green technology and sustainable architecture makes it a benchmark for eco-urban living, while its high quality of life reflects how smart planning translates into a better everyday experience for its citizens.

Oslo, Norway

Oslo has become a leading example of how technology and environmental awareness can shape the future of urban living. The city leverages digital platforms for public services and mobility, while maintaining a strong focus on green infrastructure. With widespread use of electric vehicles, smart energy grids, and an open-data governance model, Oslo sets a high standard for sustainable and transparent city management. It's a city that balances modern innovation with nature, offering a peaceful yet progressive urban lifestyle.

Canberra, Australia

Canberra is a smart capital that integrates modern digital solutions with a strong sense of environmental responsibility. It features high-speed connectivity across urban zones, smart

public services, and eco-conscious planning. The city promotes clean energy, sustainable buildings, and efficient water management systems. Canberra's calm yet innovative atmosphere makes it a model for mid-sized cities aiming to implement smart urban living without sacrificing natural harmony.

Geneva, Switzerland

Geneva is a smart city that blends global diplomacy with cutting-edge digital infrastructure. Known for its stability and high quality of life, the city has invested heavily in green mobility, digital administration, and sustainable architecture. Geneva uses smart energy systems and real-time data analytics to optimize resources, reduce emissions, and improve public services. It's a place where international values meet local innovation.

Copenhagen, Denmark

Copenhagen is a pioneer of smart sustainability, aiming to become the world's first carbon-neutral capital by 2025. The city is known for its bike-first policies, renewable energy use, and advanced digital systems for waste and water management. Smart city projects here are deeply integrated into daily life, enhancing citizen participation, efficiency, and well-being. Copenhagen shows that technology and green thinking can go hand in hand.

Lausanne, Switzerland

Lausanne is a forward-looking smart city with a strong academic and technological foundation. It is investing in digital mobility, energy optimization, and smart housing projects. With its strategic location and proximity to innovation hubs, Lausanne is developing into a center for sustainable urban experimentation. The city is committed to using data to improve public services while maintaining its unique charm and high standard of living.

London, United Kingdom

London is using its smart city infrastructure to provide public services that encompass all services, such as smart healthcare systems and real-time traffic monitoring. The city's

transport system includes buses, trains, and bike-sharing systems to help city residents get around. Another area of focus in London is green energy projects aimed at reducing carbon emissions and becoming a sustainable city.

Helsinki, Finland

Helsinki stands out for its commitment to open data and citizen engagement. The city promotes smart mobility, seamless digital public services, and environmentally conscious infrastructure. Helsinki's approach focuses on inclusivity and transparency, ensuring that every resident benefits from digital development. With extensive use of renewable energy and smart city applications, Helsinki creates a modern and sustainable urban life for all.

Abu Dhabi, UAE

Abu Dhabi is fast emerging as a regional leader in smart city development. With a vision deeply rooted in innovation and sustainability, the city is deploying advanced technologies such as AI, IoT, and big data analytics across sectors like transport, healthcare, and energy. Abu Dhabi has invested in smart traffic management, digital healthcare platforms, and real-time city monitoring systems. The city's commitment to clean energy and green architecture supports its goal of becoming a benchmark for urban sustainability in the Middle East. Blending cultural heritage with future-forward thinking, Abu Dhabi offers a unique smart city experience.

The IMD Smart City Index 2024, published by the Smart City Observatory at the IMD World Competitiveness Center in Lausanne, Switzerland, in partnership with the World Smart Sustainable Cities Organization (WeGO), sheds light on the transformative role of smart technologies in urban development.[31]