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CONTENT

ECONOMY

BLAKYTA H., GULIAIEVA N., GANUSHCHAK T.	Energy System of Ukraine: European Integration Transformations and Economic Security	4
SHKUROPADSKA D., LEBEDEVA L.	Global Trade Resilience under Uncertainty	24
MAKAROVA T.	Structural Transformations of Ukrainian Exports	42
KUSHNIR S.	Institutional Challenges to the Development of Land Capital in Ukraine	59
OSADCHA O., NIEDIELKO D.	The Contribution of Creative Industries into Economic Development of Ukraine	71
SHVETS O.	Institutional Constraints on the Digital Transformation of Ukrainian Agricultural Sector	84

FINANCE

MAZARAKI A., VOLOSOVYCH S.	AI Tokens in the Crypto Ecosystem	108
TELNOVA H.	Cryptocurrency Market as an Asymmetric Duopoly: Complementarity and Competition Between Bitcoin and Ethereum	124
APATSKYI V.	Adaptive Capacity of Ukrainian Financial Market in the Face of Military Challenges	140
USENKO A., KOPOTIIENKO T., OVCHARYK R.	Financial Analysis and Control of Public Procurement	156

MARKETING

BOIKO M., BOSOVSKA M., ROMANCHUK L.	Proactive Digital Marketing of Educational Services	178
KOPLATADZE M.	Marketing Strategies in Tourism-led Real Estate Sales and Development: Case of Georgia	206
IANKOVETS T., VYSHNEVSKA M.	FMCG-brands in the Experience Economy: the Digital Dimension	224
LEVYTSKA I.	Brands of Ukrainian Cities	244
ZAITSEVA O.	Computer Vision in Improving the Effectiveness of Digital Advertising in Retail	271

З М І С Т

ЕКОНОМІКА

БЛАКИТА Г., ГУЛЯЄВА Н., ГАНУЩАК Т.	Енергетична система України: євроінтеграційні трансформації та економічна безпека	4
ШКУРОПАДСЬКА Д., ЛЕБЕДЕВА Л.	Стійкість світової торгівлі в умовах невизначеності	24
МАКАРОВА Т.	Структурні трансформації експорту України	42
КУШНІР С.	Інституційні виклики розвитку земельного капіталу в Україні	59
ОСАДЧА О., НЄДЄЛЬКО Д.	Внесок креативних індустрій в економічний розвиток України	71
ШВЕЦЬ О.	Інституційні обмеження цифрової трансформації аграрного сектору України	84

ФІНАНСИ

МАЗАРАКІ А, ВОЛОСОВИЧ С.	Токени штучного інтелекту в криптоекосистемі	108
ТЕЛЬНОВА Г.	Крипторинок як асиметрична дуополія: комплементарність і конкуренція між *bitcoin* і *ethereum*	124
АПАЦЬКИЙ В.	Адаптивність фінансового ринку України до воєнних викликів	140
УСЕНКО А., КОПОТІЄНКО Т., ОВЧАРИК Р.	Фінансовий аналіз та контроль публічних закупівель	156

МАРКЕТИНГ

БОЙКО М., БОСОВСЬКА М., РОМАНЧУК Л.	Проактивний цифровий маркетинг освітніх послуг	178
КОПЛАТАДЗЕ М.	Маркетингові стратегії у сфері девелопменту туристичної нерухомості: кейс Грузії	206
ЯНКОВЕЦЬ Т., ВИШНЕВСЬКА М.	*FMCG*-бренди в економіці вражень: цифровий вимір	224
ЛЕВИЦЬКА І.	Бренди українських міст	244
ЗАЙЦЕВА О.	Комп'ютерний зір у підвищенні ефективності цифрової реклами в ритейлі	271

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ENERGY SYSTEM OF UKRAINE: EUROPEAN INTEGRATION TRANSFORMATIONS AND ECONOMIC SECURITY

This article examines the significance of the energy system for the functioning of the national economy and its impact on the level of the state's economic and overall security. Particular attention is paid to the energy system's ability to adapt to crisis conditions, particularly during a period of martial law, when the risks of losing generation, transmission and distribution capacity increase significantly. It is argued that the recovery and development of the sector require the modernisation of the technical infrastructure and a reorientation of resource provision in line

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ЕНЕРГЕТИЧНА СИСТЕМА УКРАЇНИ: ЄВРОІНТЕГРАЦІЙНІ ТРАНСФОРМАЦІЇ ТА ЕКОНОМІЧНА БЕЗПЕКА

Розглянуто значення енергетичної системи для функціонування національної економіки та її вплив на рівень економічної і загальної безпеки держави. Особливу увагу приділено здатності енергосистеми адаптуватися до кризових умов, зокрема в період воєнного стану, коли суттєво зростають ризики втрати генеруючих, передавальних і розподільчих потужностей. Обґрунтовано, що відновлення та розвиток галузі потребують оновлення технічної бази й переорієнтації ресурсного забезпечення відповідно

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with European approaches. The research hypothesis is that the deepening of Ukraine's integration into the European economic space creates conditions for the qualitative modernisation of the energy system, increases its resilience to external threats and contributes to strengthening the state's economic security. It is demonstrated that attracting international support and developing institutional investment mechanisms are important factors in the restoration of energy infrastructure. The theoretical basis of the study is the approach of enterprise economic security, which allows for a comprehensive assessment of the state and prospects of the energy system's development. The study employs general scientific methods, in particular analysis, synthesis and generalisation. It is generally accepted that the path towards European integration is crucial for enhancing the resilience of the energy system and creating the conditions for long-term economic growth.

Keywords: economic security, energy system, resilience, European integration, energy infrastructure, investment, development.

до європейських підходів. Дослідження ґрунтується на гіпотезі, що поглиблення інтеграції України до європейського економічного простору створює умови для якісної модернізації енергетичної системи, підвищує її стійкість до зовнішніх загроз і сприяє зміцненню економічної безпеки держави. Показано, що залучення міжнародної підтримки та розвиток інституційних механізмів інвестування є важливими чинниками відновлення енергетичної інфраструктури. Теоретичною основою дослідження є підхід економічної безпеки підприємства, що дозволяє комплексно оцінити стан і перспективи розвитку енергетичної системи. Використано загальнонаукові методи, зокрема аналіз, синтез і узагальнення. Зазначено, що євроінтеграційний вектор розвитку є визначальним для підвищення стійкості енергетичної системи та формування передумов довгострокового економічного зростання.

Ключові слова: економічна безпека, енергетична система, стійкість, європейська інтеграція, енергетична інфраструктура, інвестиції, розвиток.

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Introduction

The modern energy system is the most important component of Ukraine's economy, representing an optimally structured set of individual economic units whose activities are functionally interconnected within a unified complex for generating, distributing, and transmitting energy produced using relevant energy resources to the end consumer. The structural proportions, as well as the substance of all the system's components, have certain characteristics inherent to the national economy, macroeconomic management policies, inherited values, and accumulated technological potential.

The energy system and infrastructure were largely established in the previous century and inherited not only production assets and technologies but also the shortcomings of the command-and-administrative system, including paternalism in management, state regulation of tariffs for assessing activities, and so on. However, despite relative technological backwardness, an inertial approach to managing this part of the national economic complex, and numerous emergencies caused by shelling during martial law, a new paradigm for system management has effectively begun to emerge, thanks to the heroism of Ukrainian energy workers. This paradigm involves moving from symptomatic diagnosis to the development of analytical tools for identifying trends and directing the system's development on the basis of a new matrix of criteria, objectives, and implementation instruments. With the

support of partner countries, new technical equipment and technological configurations are being introduced into the system, modern requirements and quality standards are being established, and new mechanisms for and financial logistics are being applied. This provides grounds for asserting that Ukraine's energy system is moving towards European integration on the basis of profound internal transformations taking place alongside the restoration of its viability.

In other words, an evolutionary transformation of Ukraine's energy supply sector is underway. It is based on the principles of ensuring the economic security of each economic component and, by induction, of the system as a whole. This transformation is being implemented through crisis management tools and involves a transition to economic growth strategies aligned with the models of European countries and their approaches to assessing the relevant parameters.

The relevance of the study is determined by the need for a scientific understanding of the role of crisis management mechanisms in the activities of enterprises within Ukraine's energy sector under martial law in shaping and assessing their level of economic security according to the parameters of the European approach, establishing consistent comparability between metrics and criteria, and demonstrating the actual existence of these processes and the scale of their impact on the operational resilience of economic entities in the sector under these conditions.

A preliminary analysis of the activities of enterprises within Ukraine's energy sector indicates the fragmented application of strategic performance indicator planning, even less frequent consideration of risk factors, the absence of a comprehensive approach to determining the scope and functional interrelationships of the dominant management areas, and the assessment of factor burdens in correlation with fluctuations in indicators affected by changes in the external and internal environments.

The introduction of European experience in managing the integrated power system, which is being transferred to Ukraine as part of efforts to support its operation and enhance its resilience, is becoming a platform for reforming and modernizing the domestic management framework on the basis of security priorities and objectives aimed at improving the resilience, adaptability, and ability of the energy system to function effectively in the face of crisis challenges. This contributes to the digitalization of management, stronger coordination, risk forecasting, and a transition to a preventive model of energy security provision.

The purpose of the study is to substantiate approaches to developing an assessment model of the economic security of Ukraine's energy system under martial law and in the context of European integration, taking into account crisis management methods and European experience.

The hypothesis is that deeper integration of Ukraine into the European economic area creates conditions for the qualitative modernization of the energy system, increases its resilience to external threats, and contributes to strengthening the state's economic security.

The research methodology comprises a system of principles and methods for analysing the theoretical foundations of managing the processes through which systems attain a state of economic security by means of crisis response mechanisms, particularly under emergency operating conditions. It also involves systematizing established characteristics and interrelationships, identifying factors influencing their development, studying international experience and its current implementation in the operations of existing Ukrainian enterprises, and formulating relevant generalizations, conclusions, and proposals for their practical testing.

The scientific novelty lies in systematizing the main theoretical approaches to defining the concept of "economic security of an economic system," as well as the fundamental provisions of the organizational and methodological framework for its establishment and maintenance and the system of assessment criteria and standards. This has made it possible to unify the theoretical research model and determine the influence of sector-specific characteristics of economic activity on its underlying structure, particularly under martial law. Approaches to characterizing the state and main development trends of Ukraine's energy system as prerequisites for its integration into the European integration process have also been improved, and the factors influencing the intensity of this process have been identified.

The main body of the article consists of three sections. The first examines the prerequisites for developing the economic security potential of Ukraine's energy system in the process of European integration. The second presents a theoretical model for managing the process of achieving the target level of economic security in economic activity within Ukraine's energy system. The third substantiates the role of European integration within the system of strategic objectives and factors for strengthening its economic security potential.

1. Prerequisites for developing the economic security potential of Ukraine's energy system in the context of european integration

This issue has been addressed in contemporary academic research highlighting key aspects of the functioning of Ukraine's energy system, particularly its technical potential, resilience to external threats, and management mechanisms for ensuring energy security. At the same time, further research is needed into management tools for enhancing the resilience of Ukraine's energy system, taking into account European experience and current security challenges. The relevance of the topic is not limited to the conditions of martial law in Ukraine, which significantly intensify the impact of destabilizing factors on the functioning of the energy system, but also encompasses the specific features of its operation and development in the pre-war period. Thus, Diachenko et al. (2025) characterize Ukraine's energy sector as of February 2022 as one of the most powerful in Europe, with its

potential preserved even during wartime. In terms of electricity generation capacity, Ukraine ranks among the top ten countries in Europe, while in terms of natural gas production, it ranks among the top three, possessing some of the largest gas storage capacities in Europe.

According to Bulakh (2023), Ukraine actively cooperates with neighbouring European countries in the transportation of gas, oil, and petroleum products, as well as in electricity transmission, and has one of the largest shares of carbon-neutral electricity generation in Europe. Approximately 70% of Ukraine's electricity production is provided by nuclear, hydropower, and renewable generation. At the same time, 75% of the coal used for electricity generation is of domestic origin. The level of self-sufficiency in natural gas is approximately 67%.

According to the author, the war crisis resulted in a 4% loss of electricity generation capacity in Ukraine due to destruction and a 35% loss due to the occupation of part of the country's territory. In particular, the occupation of the Zaporizhzhia Nuclear Power Plant, the largest nuclear power plant in Europe, reduced the total generation capacity of all nuclear power plants in Ukraine by 43% (Bulakh, 2023).

In the context of ensuring the sustainable operation and development of Ukraine's energy sector, Chuhunov et al. (2023) note that integrating the energy system into the European energy space strengthens its role in ensuring national security, particularly in the political and economic dimensions. At the same time, the authors emphasize the growing importance of investment in infrastructure modernization, the introduction of technological innovations, and reform of the resource provision framework. Expanding the integrated European economic space through the inclusion of neighbouring countries, particularly Ukraine, creates new approaches to financing, promotes the development of investment models and mechanisms, and creates new opportunities for integrating domestic economic entities into the unified European economic area. For Ukraine, for example, financial support for projects through the mechanisms of the European Green Deal and relevant financial institutions is becoming accessible. This will make it possible to reduce the carbon footprint, improve other resource efficiency indicators, and strengthen the competitive position of the Ukrainian economy.

The authors consider the introduction of debt-for-climate swaps and debt-for-nature swaps in Ukraine to be a realistic prospect, as these mechanisms would make it possible to reduce the debt burden and direct financial resources towards restoring the balance of the ecosystem.

The socio-economic aspect of the sustainable development of Ukraine's energy system is the focus of Ali A.H.S. (2021), who analyzes the impact of reforms in this sector of the economy on employment levels, public well-being, and the quality of energy supply, including through the provision of resources to producers using available logistics schemes and capacities. The author assesses the role of renewable energy sources as a factor in creating new jobs, developing scientific and technological progress, increasing direct investment attractiveness and the derived attractiveness for

consumers of energy resources produced using advanced technology. Ali A.H.S. argues that the use of clean energy contributed to a reduction in unemployment in Singapore from 14% to 2% as of 2021.

The processes of the functioning and development of energy systems, transformations in the public assessment of these processes, and their specific features within the European integration model are examined by Kvasnii et al. (2024). They formulate the problem of energy poverty, which emerged during the decarbonization process, when a significant proportion of households spent disproportionately large amounts of money on energy resources or had limited access to them. As a result, the state is forced to expand support programs, introduce preferential tariffs for vulnerable population groups, promote energy efficiency measures in the residential sector, use appropriate mechanisms, and so forth.

Particular emphasis is placed on the social adaptation of communities that have historically depended on traditional coal-based energy. Modern technological transformations of the energy system, as well as progressive practices and experience in its development in European countries, the United States, and developed Asian countries, create the need to change the priorities of the economic activities of business entities and the functioning of the energy system as a whole, both at the national level and at the integrated European level. This transformation should aim to ensure a socio-economic balance between the interests of businesses, the population, and the state. Therefore, innovative environmental rehabilitation programs that do not reduce the productive capacity of the country’s economy as a whole will help lower unemployment, preserve the demographic potential of the country and its regions, and increase the value of human capital, in which investment will be made through retraining and training programs and the modernization of competency standards for small businesses. The authors substantiate the role of investment in the development of a "green" economy, which is "geared towards" the formation of new clusters of economic growth focused on environmentally safe technologies. In the authors’ view, this creates opportunities for the development of local production based on reducing regional energy dependence through the extensive use of renewable energy sources. This will strengthen the competitive position of the national economy as a whole and, in the long term, build competitiveness potential with qualitatively new parameters, criteria, and mechanisms for its enhancement.

The authors also focus on Ukraine’s European integration process, emphasizing the need to implement principles and forms of public participation in decision-making regarding the development of the energy system. In particular, this involves supporting local initiatives, establishing energy cooperatives (a new form for Ukraine), engaging citizens in energy resource management based on social responsibility and trust in state reforms, and fostering a culture of energy conservation and rational energy resource consumption, among other measures. The article concludes that

community engagement directly affects the development of the energy system in a region and the country as a whole, which, in turn, directly affects the quality of life of the population and the social cohesion of territorial communities. Thus, the prerequisites are created for simultaneously achieving energy, social, and economic objectives.

Regarding the modernization of the energy systems of territorial communities, the authors focus on the digitalization of business processes within optimal energy system management frameworks, using modern tools for monitoring, analysis, diagnostics, and control to ensure sufficient operational and management efficiency (Kvasnii et al., 2024). The authors also examine examples of the establishment of autonomous energy regions in EU countries–Denmark, France, and Germany–highlighting their impact on the sustainable development of communities that have achieved a high level of energy independence, employment, and local business success, and have established a brand and reputation for their community.

The experience of implementing effective energy-saving models is analyzed in the article by Skorokhod and Kostiuk (2021, pp. 147–153), which focuses on the implementation of intelligent energy systems in the context of the Smart Grid concept using Smart technologies. According to the data presented in the article, more than 40 cities worldwide obtain 100% of their electricity from solar power plants, wind power, hydropower facilities, and biofuels. Among these cities, the authors mention Burlington (USA), Basel (Switzerland), and Reykjavík (Iceland).

The state of development of methodological tools for the quantitative assessment of changes in indicators of economic growth, greenhouse gas emissions, and income distribution within the system is characterized in the article by Stojkoski et al. (2023), who analyze its implementation using mathematical matrices based on data on the geographical distribution of exports of energy system products, technology patents, and scientific publications in the relevant field.

Recommendations for changing the structure of Ukraine’s fuel and energy balance in the context of expanding the use of local energy resources through increased local geological exploration activities are presented in the work by Petrovets (2023).

Kohut (2023), referring to the position of the previous author, notes that the process of reforming and developing the sector requires the establishment of a favourable investment climate and a focus on long-term planning, particularly the determination of operational safety parameters for business entities, the sector as a whole, and territorial communities. The author separately examines the impact of martial law in the country in terms of its material and psychological destructiveness, the maximization of risks for investors, and the impossibility of adequately insuring the implementation of investment projects and business activities. The article presents a PEST analysis matrix reflecting the realities of key factors affecting the activities and formation of the strategic potential of Ukraine’s energy system.

The matrix metrics identify economic factors (1.147), political factors (0.847), which account for the European integration vector, and technological factors (0.553), including the impact of the decarbonization process in the energy sector, as the most influential. Sociocultural factors (0.537) have a relatively smaller impact; their assessment is based, in particular, on the significance of consumer preferences in the market for shaping the development priorities of the fuel and energy complex. The author links public health, air pollution levels, and public healthcare expenditure to the outcomes of restructuring energy supply systems in favour of energy decentralization and distributed generation. This approach will enable the population and businesses to exercise greater control over the quality and cost of energy consumption and strengthen their energy independence.

In assessing Ukraine's initial conditions for European integration, the author identifies Europe's high dependence on fossil fuels and the volatility of energy resource markets, as well as the pressure these factors exert on the competitiveness of economies. For Ukraine, which had lost a significant share of its generation capacity and infrastructure due to shelling, these issues are of critical importance, with losses amounting to USD 14.6 billion as of 2024. Fossil fuel-based energy generation sources have been affected: direct losses in thermal power generation amounted to USD 5.4 billion, while losses related to hydroelectric power plants and pumped-storage power plants amounted to USD 82.5 billion. Approximately 13% of solar generation capacity remained in occupied territories, while 8% was damaged or destroyed. As a result of destruction or loss in occupied territories, the wind power generation system lost up to 80% of its production assets (Kohut, 2023).

In June 2024, at the Ukraine Recovery Conference in Berlin, the following estimates were announced by Ukraine's energy system partners:

- United States of America – USD 824 million to support energy infrastructure;
- World Bank – an additional grant of USD 47 million for the procurement of heating equipment for Kharkiv, including 1,000 generators and solar panels;
- European Union – initiation of solar panel supplies;
- Germany – EUR 30 million to improve the reliability of the energy system (UkraineInvest, 2024).

The conference also presented a new strategy for the development of Ukraine's energy system through 2050, which envisages increasing wind power generation capacity to 140 GW, solar power generation capacity to 94 GW, energy storage capacity to 38 GW, nuclear power generation capacity to 30 GW, combined heat and power plants (CHP) and bioenergy capacity to 18 GW, and hydropower generation capacity to 9 GW. According to estimates based on the TIMES model, this programme requires USD 383 billion in direct capital investment (Ministry of Energy of Ukraine, 2023).

2. Theoretical model for managing the process of establishing the target level of economic security in economic activity within Ukraine's energy system

The theoretical model for the formation and management of a system's state, taking into account the requirements for ensuring a certain level of economic security, is based on the conceptual consistency of definitions, indicators, and criteria in accordance with the currently accepted paradigm of managing financial and economic activities, both at the level of an individual business unit and that of integrated systemic entities.

By systematizing scholars' theoretical approaches to defining the essence of the concept of "economic security," common features of their academic positions can be identified. Thus, Kuzenko and Sablina (2020, p. 13) interpret economic security as a state of efficient resource utilization, defining it in terms of the level of effective use of financial and material assets, as well as market opportunities, which helps prevent internal and external threats and ensures stable market growth in accordance with established objectives. Zubko (2021, p. 17) adopts a similar position, considering the economic security of a business entity to be the systemic operation of a mechanism for the effective mobilization and management of a company's corporate assets, aimed at maximizing their utilization to ensure its stable operation and ability to counteract any negative factors that may affect the economic security of the business entity.

Melikhova (2018, p. 24) brings together approaches based on the criterion of "economic security as a state of protection," considering the economic security of an economic system to be a process-based substance. She characterizes the concept as the effective management of a security service with functions that guarantee the sustained security of operational activities and help preserve an organization's economic independence in the face of external challenges, ensure rapid adaptation to new market conditions, minimize undesirable consequences, and optimize the management of enterprise resources to achieve strategic objectives.

Alkema et al. (2019, p. 22) interpret economic security as a comprehensive, multi-stage hierarchical system with a complex structure that ensures the security of business processes through the efficient use of an enterprise's economic potential and is aimed at preventing internal and external threats. This system is implemented through a set of specialized legal, economic, and organizational measures. Marchenko (2022, p. 57) also emphasizes the systemic and process-based nature of economic security, viewing it as a set of management processes aimed at ensuring an enterprise's stability and protection from adverse internal and external environmental factors throughout its entire operational cycle. The author further specifies the concept as a comprehensive management process that ensures the continuous development of an enterprise and affects the efficiency of its economic activities in both the short and long term.

An in-depth definition of the essence of economic security as a state of comprehensive business activity is presented in the study by Sytnyk et al. (2019). The authors consider it a distinct function that is shaped by the influence of various factors and ensures stable development, financial reliability, the country's competitiveness, and public well-being. In subsequent studies, this approach is further specified with regard to the functioning of individual business entities.

In general, the above definitions consider economic security in terms of a set of means and mechanisms for ensuring a state of an economic system in which it meets established criteria for economic protection against the adverse effects of external and internal environmental factors. This state characterizes an economic system's ability to function stably and achieve established objectives under normal business conditions.

Different approaches share the fundamental characteristics of the state of economic security in business activity, namely, financial stability and an active investment position in pursuing development through innovative ideas for technological modernization and environmental sustainability, while taking into account the requirements of the regulatory environment at both the regional and national levels.

However, further discussion and development of this issue require the search for a universal theoretical construct and its adaptation to specific industry contexts. It is indisputable that the key consideration in this search is the understanding that the economic security of an economic system is not an end in itself; rather, it is a tool and a means of harmonizing the interests of all components involved in interactions with the external environment, including counterparties and business partners, local and national institutions, as well as those within the internal sphere, such as employees.

At the top of the pyramid of an economic system's interests are economic interests, which reflect efforts to achieve high product competitiveness and a secure market position, sustainable marketing prospects, an optimal pricing policy, rational expenditure, and a sufficient level of profitability with minimal risks.

The social interests of an economic system within the framework of security guarantees include providing jobs, ensuring that employees' competencies meet job requirements, maintaining a rational intensity of their utilization, establishing a justified level of remuneration while complying with social protection standards and ensuring high discipline in their implementation, providing a social benefits package, offering opportunities for professional growth, and so forth.

Political interests within the security framework of an economic system's activities are manifested in its alignment with the principles, methods, and business ideology of public administration in the country.

An important component of the spectrum of interests of a business entity and its interaction environment is environmental interests, which are

associated with the economic assessment of and issues related to environmental protection. These are addressed through autonomous investments, compensatory sanctions for pollution incidents, and other economic mechanisms within the modern management paradigm.

The range of interests of agents within the interaction environment of an entity, whether operating as an individual or a consolidated economic system, can be significantly expanded depending on the specific industry and subject area of its activities. These include, in particular, attributed, compulsory, global, and strategic interests, among others.

The nature, sources, and intensity of threats and hazards capable of impeding the realization of economic interests and undermining the stability of an economic system's functioning are identified in accordance with the substance of those interests.

This theoretical position reveals the multifaceted nature of the model for managing the establishment and maintenance of the stability of an economic system's economic security. Under the general approach, the model is structured into functional blocks that determine the specific features of the methodological basis for assessment and the instruments of influence. This approach to management organization makes it possible to rationalize expenditure significantly and improve the quality of decision implementation through greater performance and efficiency.

It is clear that the economic system's industry affiliation significantly modifies the content of these components while preserving the basic configuration of the overall structure and general assessments. The decomposition of the business entity's operational security system is presented in *Figure 1*:

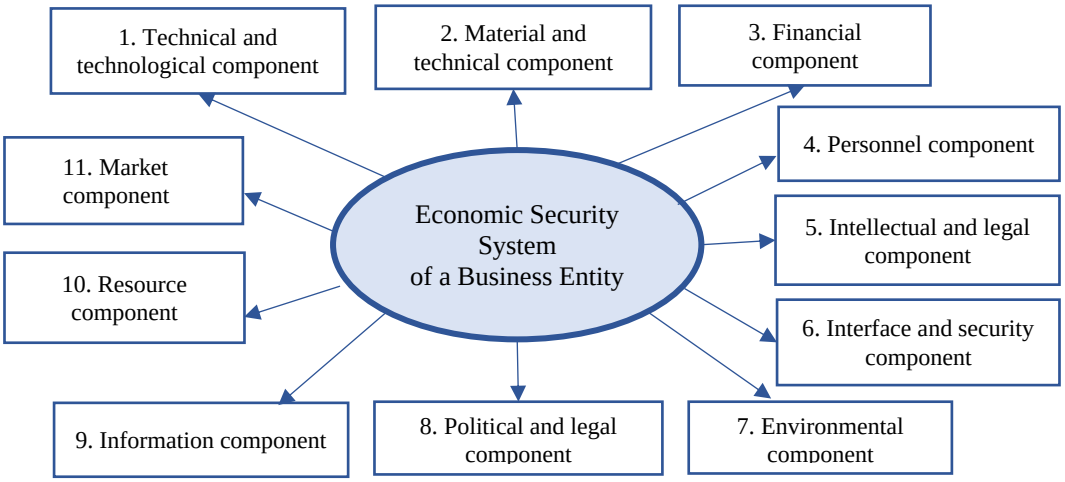


Figure 1. Components of the economic security system of a business entity

Source: compiled based on (Zubko, 2022, pp. 277–278).

The practice of managing the establishment and maintenance of economic security within accepted criteria is based on a generally recognized theoretical model for the scientific substantiation of relevant management

mechanisms, as well as on established methodological principles and methodological approaches to identifying and assessing its parameters.

At the current stage, scientific generalizations of various approaches are systematized into the following groups according to the similarity of the tools used for their implementation: indicator-based (threshold), resource-functional, program-target (comprehensive), risk-dependent, investment-profitability, and economic-mathematical approaches, which are used in assessment procedures based on the corresponding methods. The methodological toolkit for assessing an enterprise's level of economic security includes integral assessment methods, functional dependence methods, the indicator-based method, point-based assessment methods (the rating approach), hierarchical levels of economic security, the graphical method, and fuzzy logic theory.

The system of assessment parameters requires information support based on publicly available financial and statistical reporting (SRM, BAS ERP, IT-Enterprise, Debet Plus, Prozorro, Prozorro Market, YouControl). For internal analysis, management accounting data are used. The structuring and calculation of derived indicators depend on the assessment methodology adopted by the analyst, which is substantiated by the specific methodological approach.

The universality of theoretical generalizations and approaches to information support for the processes of managing the establishment of an economic security system, structured around dominant functional blocks, abstracts the analytical field from industry-specific characteristics. However, it makes it possible to account for the industry-specific features of an economic system in matrices of criteria and indicator weighting scales, and to influence them through operational interventions and adjustments to long-term objectives.

The theoretical model for managing the process of ensuring an appropriate level of economic security for an economic system is generally suitable for application under extraordinary operating conditions, which characterize the current situation in Ukraine as a result of the full-scale invasion by the Russian Federation. The specific features of this period require the inclusion of crisis management tools in the overall management response framework, reflecting changes in criteria, metrics for assessing parameters, resource support, and so forth. Under these conditions, the role of risk management, an optimization-based approach to resource provision management, personnel management, the integration of innovation into technological solutions, and an organizational and economic mechanism for responding promptly to crisis events becomes increasingly important.

It is under precisely these conditions that Ukraine's energy sector currently operates. As a result of intensive Russian shelling, it is no longer in a state of crisis but has reached a critical state characterized by property losses and a high probability of economic collapse. The severity of the situation is classified not according to the economic security criteria

applicable to the business entities integrated into the system, but according to the parameters of technical and, subsequently, economic survival, although these aspects constitute a single whole and are inextricably interdependent. Current assessments of the situation are framed in terms of energy security as a fundamental component of Ukraine's national security. In recent years, Ukraine has intensified its participation in the European integration process, combining efforts to restore capacity across all sectors of the energy industry with its reform, modernization, upgrading of resource provision, and alignment with the operational standards of the integrated European energy system according to comparable parameters of progressiveness and economic and technological security.

3. European integration within the system of strategic objectives and factors for strengthening the economic security potential of Ukraine's energy system

The security of Ukraine's energy system is not an additive characteristic of its state, as it comprises not only the parameters of individual elements but also has a synergistic nature of formation, as well as macroeconomic assessments and areas of intervention that involve a high degree of state regulation against the backdrop of achieving an energy balance and an independent level of energy resilience within the framework of national security strategy and policy. This approach is not exclusive; it is applicable not only to countries with advanced economies. During structural economic and political shifts toward integration, the initiators and implementers examine and ensure the comparability of project configurations both in terms of their individual components and as a whole, particularly in energy integration models.

This is precisely the task facing Ukraine in the process of European integration under the challenging conditions of almost four years of destruction of national assets, particularly in the energy sector.

An in-depth, comprehensive analysis of all the characteristics of Ukraine's energy system is carried out on an ongoing basis and incorporated into established model templates to ensure continuous monitoring of the system's economic security margin as it seeks to become part of the established European energy framework. This analysis covers structural features and the proportions of business entities of various legal forms and ownership types; the presence or absence of monopolistic distortions in different energy market sectors; the degree of market liberalization and efficiency; the state of market participants' market valuation, including their investment value; and the calculation of key indicators of the resilience of financial and economic activities at the level of individual enterprises and the integrated system. These processes are reflected in the conclusions and recommendations of A Competitiveness Strategy for Europe (2024), as well as in investment support plans for the development of green energy in Ukraine,

particularly solar and wind power, and for increasing renewable energy capacity while reducing the share of coal and other energy resources used in energy complexes that generate greenhouse gas emissions. For comparison, according to WindEurope (2024) and SolarPower Europe (2024), in 2023–2024, wind power accounted for approximately 17–18% of electricity generation in the European Union, while solar power accounted for approximately 9–10%, representing the highest growth rates among renewable energy sources. Hydropower accounted for only 12–13% of electricity generation, nuclear power for 22–23%, and other sources (bioenergy, coal, gas, oil, etc.) collectively accounted for approximately 27–30% of the integrated energy mix (Ember, 2024).

The differences between Ukraine's and the EU's approaches to energy balance formation are outlined in Investment Opportunities of the Energy Sector (*Figure 2*).

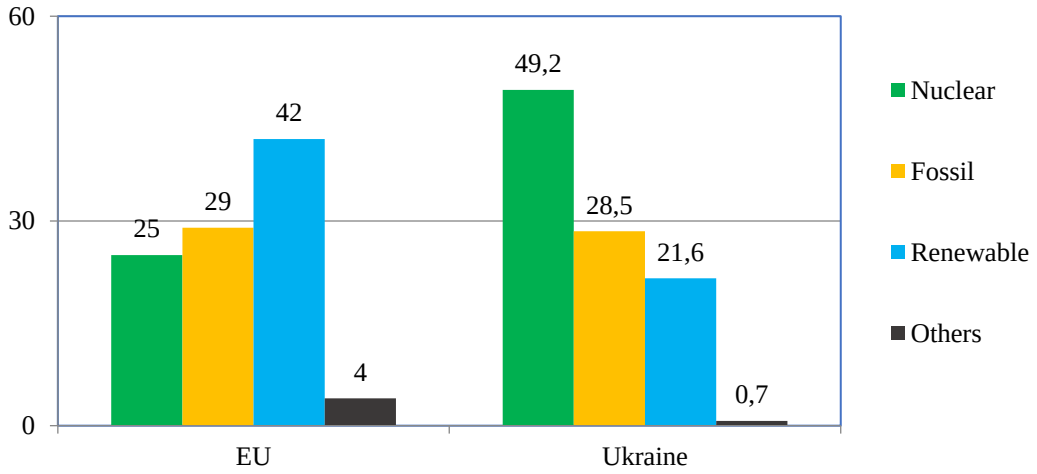


Figure 2. Energy sources in Europe and Ukraine, %, 2023
Source: compiled based on (Investment Opportunities of the Energy Sector, 2024).

While Ukraine continues to prioritize its dependence on nuclear power (49.2%), the EU is pursuing a strategy aimed at minimizing such dependence. At the time of the study, nuclear power accounted for 25% of the total energy sources. The use of fossil fuels in the systems being compared was almost identical: 29% in the EU and 28.5% in Ukraine. Moreover, the EU significantly outperformed Ukraine in the use of renewable energy sources, accounting for 42% compared with 21.6% in Ukraine. In Ukraine, other sources (0.7%) were not included among the actively utilized sources, whereas in the energy balance of the EU's integrated energy system, they accounted for 4%.

Clearly, Ukraine's European integration strategy should provide for the reform of the national energy system along development vectors aligned with the EU's development priorities and criteria for system compatibility, thereby enabling its full integration while preserving the resilience of the

established overall balance and the economic security margin of this complex integrated energy system.

In addition to technological analysis, a key component of studying the integration of Ukraine's energy system is the comparative analysis of the organizational and economic mechanisms governing its operation. Despite the similar broad structural composition of the EU and Ukrainian energy systems – comprising the generation, distribution, and supply of energy resources – their proportions in terms of activity volumes differ. Thus, according to Ember (2024), Eurostat, and the IEA, in 2024–2025, the EU electricity sector consisted of generation, accounting for 60% (€ 480–550 billion); distribution and transmission, accounting for 20% (€ 170–220 billion); and supply, accounting for 20% (€ 180–230 billion). In Ukraine, the corresponding proportions were 65% for generation (UAH 210–260 billion), 20% for transmission and distribution (UAH 70–95 billion), and 15% for supply (UAH 55–75 billion).

Among the factors influencing the achievement of system comparability, the structural characteristics of business entities' presence in the "energy resource production – supply" chain should be noted in terms of their legal and organizational forms and types of ownership. For example, according to Eurostat, ENTSO-E, and European Commission reports (2023–2024), in the EU, up to 65% of enterprises operating in electricity generation and supply are joint-stock companies, 25% are business companies, and 15% represent other forms of business organization, including specialized associations such as concerns, associations, and conglomerates established on a statutory or contractual basis. Thus, the overwhelming majority of the sector belongs to joint-stock and corporate structures, while state-owned or collective forms are less prevalent and often take the form of large national or transnational concerns. Ukraine is characterized by the significant market shares of major producers, with Energoatom accounting for 50%, and energy traders such as DTEK, accounting for 45%, which hold near-monopolistic positions in Ukraine's energy market. The remaining market participants (small private generators and renewable energy enterprises) account for only a limited share, approximately 10–15% of total electricity generation (IEA – Electricity Generation by Source, Ukraine, 2025). Thus, DTEK is effectively the largest private player in Ukraine's electricity market, alongside the state-owned Energoatom, which dominates the nuclear sector, accounting for approximately 50% of electricity generation.

Among the factors that have a decisive influence on the fundamental economic principles governing the activities of energy system enterprises are the mechanism of state regulation, the degree of liberalization of the energy market, and market players' freedom to choose the type and content of their pricing policies based on an assessment of interactions among the main market elements and market conditions along actual and projected trajectories of change.

The EU market is characterized by the formation of prices for energy products and services in accordance with objective trends in supply and demand, taking into account speculative market fluctuations. EU Member States address issues of social protection for the population without removing them from market mechanisms. In Ukraine, however, state regulation of energy resource prices for end consumers remains in place, while the performance of all system components is assessed according to the reverse principle. Existing cooperation with the EU energy system through critical energy imports has exacerbated this imbalance, creating a crisis situation for energy traders unless state support is provided or tariff scales for domestic energy consumption are adjusted (A Competitiveness Strategy for Europe, 2024; IEA – Electricity Market Report: Ukraine, 2024).

Green energy tariffs are not comparable. In Ukraine, they are the highest in Europe (until 2030), making the development of this energy source unattractive for business investment. In addition, a factor reducing the quality of Ukraine's energy system operations and development is relatively poor payment discipline at all stages of financial logistics. Extensive chains of non-payments are reflected in all parameters of the economic security models of market participants, further reducing assessments of the system's attractiveness for investment and its suitability for integration into the unified energy complex.

The assessment tools adopted in analytical practice for determining the level of economic security of a business entity or an integrated economic system are based on financial performance indicators and their dynamics over the period under study. These include indicators of solvency, business activity, financial independence, creditworthiness, and others, as well as the relationships between individual performance characteristics, particularly the rates of change in revenue and assets based on their market valuation.

The analytical framework also incorporates performance results relating to the production and technical, intellectual and human resources, and commercial components within the current and tactical reporting periods. The specific set of indicators is determined with due consideration of the strategic aspects of operations, namely market-related, social, and innovation and technology-related aspects. The comparability of indicators is ensured through the application of international accounting standards and management accounting models commonly used in Ukraine.

Despite substantial technical assistance not only in preserving, restoring, and developing Ukraine's energy system assets according to critical priorities and requirements, the European integration process will acquire a multifaceted scope and high intensity as the country achieves maximum comparability in its economic and organizational operating mechanisms, the technological base for energy product generation, and the delivery of energy products and services to end consumers, as well as consistency in approaches to assessing the level of economic security as a component of national security as a whole.

Achieving adequate values for the economic security indicators of Ukraine's energy system is a prerequisite for its European integration as a worthy member of the European energy community. Conversely, the European integration of Ukraine's energy system is a well-founded strategic decision and a means of strengthening its economic security potential.

Conclusions

The study entitled "Economic Security of Ukraine's Energy System under Martial Law and European Integration" established that Ukraine's energy system is a key factor in ensuring economic and national security, while its level of resilience directly determines the stability of the national economy. It was also substantiated that European integration creates institutional and economic prerequisites for the recovery and modernization of the energy system on a modern technical and technological basis, while an increase in the level of economic security serves as a driver of integration processes.

It was demonstrated that, under martial law, energy system management is shifting towards crisis management, which requires the adaptation of methodological tools for assessing economic security. Despite infrastructure losses, Ukraine's energy system retains significant production potential and ensures gradual integration into the European energy space.

The study substantiated approaches to developing an assessment model of the economic security of the energy system, taking into account wartime challenges and European integration processes, as well as the expediency of applying crisis management methods and drawing on European experience.

The interdependence between the level of economic security of the energy system and the effectiveness of European integration was established: achieving appropriate security parameters is a prerequisite for integration, while integration is a factor in strengthening these parameters, thereby confirming the proposed hypothesis.

Prospects for further research are associated with the development of optimization models for ensuring the economic security of Ukraine's energy system, taking European standards into account and focusing on achieving a synergistic effect.

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GLOBAL TRADE RESILIENCE UNDER UNCERTAINTY

The article addresses the problem of ensuring trade resilience under conditions of increasing global uncertainty, market fragmentation, and intensifying geoeconomic competition. The relevance of the study follows from the transformation of the global trade system, where external shocks, such as pandemics, tariff restrictions, supply chain disruptions, and climate-related risks, have become systemic rather than episodic, making trade resilience a key determinant of national competitiveness.

The hypothesis of the study states that trade resilience is determined by the level of diversification of trade linkages, the depth of integration into global and regional production networks, and the quality of the institutional environment shaping regional resilience clusters. The aim of the article is to identify the patterns underlying the formation of trade resilience under conditions of global uncertainty and to substantiate the influence of structural and regional factors on the ability of economies to withstand external trade shocks. The methodological framework is based on comparative analysis combined with an index-based approach. The empirical foundation relies on the Global Trade Resilience Index (GTRI), used for cross-country and cross-regional comparisons. The findings empirically confirm the proposed hypothesis.

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СТІЙКІСТЬ СВІТОВОЇ ТОРГІВЛІ В УМОВАХ НЕВИЗНАЧЕНОСТІ

Висвітлено проблему забезпечення стійкості торговельної діяльності в умовах зростання глобальної невизначеності, фрагментації ринків та посилення глобальної конкуренції. Актуальність розвідки зумовлена трансформацією світової торговельної системи, в якій зовнішні шоки, зокрема пандемія, тарифні обмеження, порушення ланцюгів постачання та кліматичні ризики, набули системного, а не епізодичного характеру, роблячи стійкість торгівлі ключовим чинником національної конкурентоспроможності.

Дослідження ґрунтується на гіпотезі, що стійкість торговельної діяльності визначено рівнем диверсифікації торговельних зв'язків, глибиною інтеграції у глобальні та регіональні виробничі мережі, а також якістю інституційного середовища, що формує регіональні кластери стійкості. Метою дослідження є виявлення закономірностей формування стійкості торговельної діяльності в умовах глобальної невизначеності та обґрунтування впливу структурних і регіональних чинників на здатність економік протидіяти зовнішнім торговельним шокам. Методологічно дослідження ґрунтується на порівняльному аналізі у поєднанні з індексним підходом. Емпіричну

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Higher levels of trade diversification and deeper integration into production networks reduce vulnerability to external shocks and enhance adaptive capacity, while institutional quality acts as a system-forming factor that strengthens coordination and predictability. The conducted analysis revealed significant regional heterogeneity in the impact of the U.S. isolationist tariff policy: European economies demonstrate the highest resilience, whereas Mexico, Canada, and Vietnam exhibit greater vulnerability. The obtained results highlight the need to implement policies aimed at diversifying trade flows, deepening integration into production networks, and strengthening institutional capacity. The analysis reveals significant regional heterogeneity in the impact of U.S. isolationist tariff policies: European economies demonstrate the highest resilience, whereas economies highly dependent on the U.S. market exhibit greater vulnerability. The results substantiate the need for policies focused on diversification, deeper integration, and strengthening institutional capacity to ensure trade resilience.

Keywords: trade resilience, global trade, regional trade clusters, institutional quality, trade shocks, economic resilience, Global Trade Resilience Index (GTRI).

базу становить Global Trade Resilience Index (GTRI), який використовується для порівняння країн та регіонів. Результати дослідження емпірично підтверджують висунуту гіпотезу. Вищий рівень диверсифікації торгівлі та глибша інтеграція у виробничі мережі знижують вразливість до зовнішніх шоків і підвищують адаптивну спроможність, тоді як якість інституцій виступає системоутворюючим чинником, що посилює передбачуваність та координацію економічних процесів. Проведений аналіз виявив значну регіональну неоднорідність впливу ізоляціоністської тарифної політики США: європейські економіки демонструють найвищу стійкість, тоді як Мексика, Канада та В'єтнам демонструють більшу вразливість. Отримані результати засвідчують необхідність реалізації політики, спрямованої на диверсифікацію торговельних потоків, поглиблення інтеграції у виробничі мережі та підвищення інституційної спроможності.

Ключові слова: стійкість торгівлі, глобальна торгівля, регіональні торговельні кластери, якість інституцій, торговельні шоки, економічна стійкість, *Global Trade Resilience Index (GTRI).*

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Introduction

One of the key expressions of the growth of global uncertainty in 2025 in the field of international trade was the transformation of US trade policy. The introduction of additional duties on certain categories of goods (in particular, steel), the escalation of the trade confrontation with China, as well as the spread of tariff restrictions to most US trading partners significantly increased the turbulence of the global trading environment.

Seeking to minimize the impact of exceptionally high tariffs, U.S. trade partners were compelled to adapt to the new rules of the game by concluding bilateral agreements that partially mitigated the tariff regime. The partial restriction of access to one of the world's largest markets stimulates trade reorientation, diversification of partnerships, and the search for alternative distribution channels, which becomes a key factor in ensuring the resilience of trade activity under conditions of global uncertainty.

The need to rethink approaches to the formation of trade policy and the organization of international economic interaction is gaining particular importance. Traditional models based on predictability and liberalization are giving way to strategies of diversifying partnerships, strengthening digital infrastructure, regional integration, and increasing institutional flexibility.

Thus, the study of the resilience of trade activity under conditions of global uncertainty is both timely and necessary, as it is aimed at developing

the theoretical and practical foundations for enhancing the adaptability of trade systems to external shocks and ensuring their long-term competitiveness.

Modern economic science views resilience not merely as a system's ability to return to its original state but as a complex process of dynamic adaptation and transformation. Literature identifies three levels of defense in trade systems: absorptive capacity (the ability to absorb shocks without loss of functionality), adaptive capacity (the ability to reorganize internal processes), and restorative capacity (the speed of returning to target indicators) (Gaudenzi, 2024).

Uncertainty acts as a hidden tax on investment, causing firms to delay capital-intensive projects and reduce export activity. Recent research further clarifies that the impact of uncertainty is nonlinear, particularly as countries reassess offshore investments after the COVID-19 pandemic and increasingly reorganize supply chains toward politically, culturally, and geographically aligned partners through the concept of friendshoring (Özsalman & Bayat, 2025; Jakubik & Ruta, 2023).

Recent studies have shifted focus toward how supply chain structures determine resilience. Ferrari and Pesaresi (2025) propose a theory of supply chain formation where intermediate producers choose to "over-specialize" their goods to increase productivity during normal times. However, this creates a network externality: such specialized inputs are harder to replace after a shock, making the overall system less resilient than is socially desirable.

The affect of geoeconomic pressure as on trade activity of enterprises was measured by Clayton et al. (2025). They utilize large language models to show that firms respond differently based on the instrument of pressure: tariffs primarily lead to price changes, whereas export controls force firms to disproportionately increase investment in R&D to ensure technological sovereignty. Similary, Shkuropadska (2018) assessed the level of resilience of Ukraine's external sector by analyzing economic indicators and shock influences between 2008 and 2016. The findings show that external sector of economy exhibits high sensitivity to nominal and real shocks, such as debt growth and GDP reduction.

The links between resilience and automation and reshoring was investigated by Firooz et al. (2025) who argue that trade uncertainty creates an "expenditure-switching effect," encouraging firms to reshore production. However, this reshoring is often coupled with increased automation to maintain productivity, which can weaken the bargaining power of low-skilled workers and increase wage inequality.

Grossman et al. (2023) address the optimal policy debate, suggesting that while reshoring is often touted by policymakers, subsidies for international diversification are more likely to achieve social optimum than forcing production back home. This is supported by Faber et al. (2025), who state that high uncertainty in developing countries with advanced automation technologies (robots) drives the reshoring of global value chains to high-

income countries. Correspondingly, Afonso et al. (2024) suggest that in times of extreme uncertainty, nations tend to concentrate their trade among their top 5 most reliable partners to minimize coordination costs.

Chunikhina et. al. (2024) explore how global shifts, including geopolitical upheavals and technological innovations, impact international alliance strategies and trade policies. They find that the protectionitic measures and shifting political orders disrupt global supply chains, forcing states and businesses to adapt by diversifying trading partners and increasing regional cooperation.

Li and Jiang (2025) investigate how the development of service trade contributes to strengthening export resilience at the regional level. They find that expansion in service trade, such as IT, financial, and tourism services, significantly improves a region's capacity to maintain and recover export performance in the face of external shocks, thereby improving export resilience. To support that, provincial data in China shows a significant positive effect of digital trade on regional economic resilience (Wan & He, 2025).

Regional trade agreements remain the primary institutional mechanism for reducing uncertainty. Research confirms that "deep" regional trade agreements effectively mitigate the negative impact of domestic uncertainty on exports (Bag, Sun chan, 2025). This is suppotred by Melnyk and Kovalova (2023) on the example of positive affects of regional agreements, partiulary "customs visa-free" status of Ukrainian traders on EU market on the competitiveness of Ukrainian goods.

The hypothesis of the article states that the resilience of trade activity is determined by the level of diversification of trade chains, the depth of integration into global and regional production networks, and the quality of the institutional environment that shapes regional clusters of resilience.

The aim of the article is to identify the patterns underlying the formation of trade resilience under conditions of global uncertainty and to substantiate the influence of structural and regional factors on the ability of economies to withstand external trade shocks.

This study applies a comparative cross-sectional *research methods* to examine the structural and regional determinants of trade resilience under conditions of global uncertainty. Trade resilience is conceptualized as a multidimensional characteristic shaped by (i) diversification of trade linkages, (ii) depth of integration into global and regional value chains, and (iii) quality of the institutional environment forming regional resilience clusters. The empirical analysis is primarily based on the Global Trade Resilience Index (GTRI), which serves as a composite indicator for cross-country and cross-regional comparison. Forecasts and scenario projections from the Whiteshield platform are used to assess the differentiated regional impact of the "U.S. trade shock".

The methods used combine systemic and structural-functional analysis with index-based comparative assessment. Cross-sectional analysis of GTRI scores was used to identify regional clusters, stratification patterns,

and structural asymmetries in resilience capacity. Descriptive statistics and comparison analysis were employed to explore relationships between diversification, network integration, institutional quality, and resilience outcomes.

The structure of the article is as follows. First, the factors ensuring the resilience of trade activity are analyzed. Next, the level of resilience of regional trade clusters is assessed based on the Global Trade Resilience Index (GTRI). Finally, the regional impact of the U.S. trade shock is determined through a comparison of GTRI data with forecasts provided by the Whiteshield platform.

1. Factors ensuring trade resilience

Global trade operates in conditions of permanent affects of destabilizing factors of geopolitical conflicts and economic shocks, such as COVID-19 crisis, trade war between the USA and China. The combination of these factors causes the increase in volatility of international markets and actualizes the problem of ensuring trade resilience as a systemic characteristic of national economies. Today, trade resilience is considered not as an additional advantage, but as a strategic prerequisite for maintaining the continuity of the movement of goods, services and capital and ensuring macroeconomic stability.

Theoretical understanding of the category of "trade resilience" involves its interpretation as the ability of the economy to absorb external shocks, adapt to changes in the global environment and transform the structure of trade relations without losing long-term competitiveness. The formation of trade resilience is based on a number of interrelated components, including diversification of trade partnerships, development of transport and digital infrastructure, availability of effective financial protection mechanisms, as well as flexibility of state policy and labor market.

Analysis of historical retrospective of global trade shocks from the Great Depression of the 20th century to modern tariff conflicts shows that economies that proactively invest in ensuring the structural foundations of resilience demonstrate a higher level of adaptability and recovery from crisis events. At the same time, the strengthening of protectionist tendencies and the growth of geo-economic tensions are shaping new scenarios for world trade development, which require a reorientation of state and business strategies towards long-term risk management.

Trade resilience should be interpreted as an integral characteristic of the national economy, reflecting its ability to counteract external trade shocks, minimize their negative impact and ensure continuity of goods movement, services and capital. In this context, resilience is not only a reaction to crisis phenomena, but a systemic property of the state’s trade model.

From the standpoint of a *functional approach*, a resilient trade system is characterized by three interrelated capabilities: first, *the ability to absorb* short-term shocks using financial reserves, stabilization policy instruments

and rapid response mechanisms; second, *adaptability* in the medium term through the diversification of sales markets, changing logistics routes and reorienting suppliers; third, the *ability to recover* and transform in the long run, which involves the structural modernization of industries, updating trade strategies and increasing competitiveness. Thus, trade resilience is a dynamic category that combines elements of stabilization, adaptation and strategic development, forming the basis for ensuring the long-term economic resilience of state in conditions of global uncertainty.

The formation of a resilient trade system is based on a complex of interrelated structural and institutional factors, the effectiveness of which is confirmed by the empirical evidence of different countries (*Table 1*). The combination of these complementary factors determines the ability of the national economy to respond in a timely manner to external trade shocks, minimize their negative consequences and ensure the stability of foreign economic activity in the long term.

Table 1

Factors ensuring the resilience of a country's trade activity

Factors	Description
Diversification of Trade Partners and Products	Reducing dependence on specific countries or narrow product specialization by expanding the geography of exports and imports and diversifying the product range
Participation in Global Supply Chains	Integration into international production and logistics networks, providing access to technologies, markets, and resources, and enhancing competitiveness
Maintaining of Strategic Reserves and Resource Security	Building reserves of critical resources (energy, food, raw materials) to minimize the risks of supply disruptions
Geo-Strategic Location and Trade Routes	Leveraging advantageous geographic positioning to develop transit potential and diversify logistics routes
Developed Infrastructure and Logistics	Availability of modern transport, port, digital, and warehousing infrastructure ensuring the continuity of trade flows
Access to Trade Finance and Insurance	Availability of effective mechanisms for financing, guarantees, and insurance of export-import operations to reduce financial risks
Strong Institutions	Quality of governance, stability of the regulatory environment, and efficiency of customs and control procedures
Flexible and Skilled Labor	The ability of the labor market to quickly adapt to structural changes, supported by a workforce with relevant skills and competencies
Agile Trade Policy and Crisis Response	The capacity of the state to promptly adjust trade instruments in response to changes in the external environment
Stable Economy	Low inflation, manageable public debt, a stable currency system, and overall financial balance
Access to Multiple Trade Routes	The ability to reorient trade flows through alternative transport corridors in case of disruption of primary routes
Robust Domestic Demand	A developed domestic market capable of partially offsetting external losses and sustaining economic activity

Source: (Whiteshield Partners, 2025a).

Diversification of trade partners and products is an important mechanism for reducing economic risks for a country. Excessive dependence on a limited number of export markets or a single product makes the economy vulnerable to external shocks and instability in the world market. Expanding

the range of trading partners and product range allows for effective risk sharing and ensures the stability of foreign trade. An example of successful diversification is Canada, which, going beyond the traditional US market, has concluded agreements such as CETA with the European Union and CPTPP with countries in the Asia-Pacific region (Donovan et al., 2025). Accordingly, this has provided the country with alternative buyers and suppliers, reducing the risks associated with protectionist policies and fluctuations in the world economy. Thus, diversification not only increases the economy's resilience to external shocks, but also expands access to new markets even during periods of global economic downturns.

Participation in global supply chains is also an important factor in increasing trade resilience. Integration into regional and global production networks promotes specialization, expands access to external markets, and at the same time provides greater flexibility to shocks. A good example is Thailand, which benefits from deep integration into East Asian production networks and participation in agreements such as RCEP (Srisangnam, 2024). Accordingly, this allows the country to quickly change its sources of supply and export destinations in the event of external shocks.

Strategic reserves and resource security involve the formation of stocks of critical resources and the diversification of their supply sources, which create an additional buffer of protection in crisis situations. Following China's introduction of restrictions on rare earth metal exports in 2010, Japan implemented a comprehensive policy of import diversification, invested in the recycling of secondary raw materials, and expanded its strategic reserves (World Trade Organization, 2023). Accordingly, this allowed the country to reduce dependence on a single supplier and increase autonomy in critical sectors.

Geostrategic location and trade routes are associated with the country's geographical advantages. In particular, access to several transport corridors and transit routes allows for diversification of logistics routes and minimizes the risks of disruptions in the event of regional instability. A good example is Turkey, which is located at the crossroads of Europe and Asia. Using infrastructure investments and regional trade agreements, the country maintains the stability of trade flows even in the face of geopolitical tensions in neighboring regions (Aguiar, 2025, July 16). Similarly, Panama gains strategic advantages through control of the Panama Canal, which provides the ability to quickly redirect maritime trade flows during periods of global logistical disruptions.

Developed infrastructure and logistics are key prerequisites for trade resilience, as efficient transport and logistics systems enable the rapid redirection of trade flows in times of crisis. The availability of modern ports, multimodal hubs and developed warehousing areas reduces transaction costs and minimizes the risks of delays in delivery. A good example is the Jebel Ali Port in Dubai, which, combined with extensive logistics areas, has enabled the region to maintain its status as a key distribution hub during the

COVID-19 pandemic. Thanks to a high level of infrastructure readiness and flexibility in logistics services, trade continuity has been ensured even in the face of global supply chain disruptions (García-Alzórriz, 2020, April 9).

Access to trade finance and insurance is a strategic component of maintaining business liquidity during economic downturns. Trade credit, export guarantees and insurance instruments reduce the risks of non-payment and ensure the continuity of foreign trade activities even in conditions of increased uncertainty. One example is the creation in 2020 of the Export-Import Bank of Saudi Arabia, which provided loans and insurance instruments to support non-commodity exporters during the COVID-19 pandemic. Accordingly, this allowed to maintain foreign trade volumes and mitigate the negative impact of the global recession (World Trade Organization, 2019).

Strong institutions and policy frameworks are a fundamental prerequisite for trade resilience. Transparent, predictable and consistent trade policies reduce uncertainty for economic agents and enable a rapid response to crises. New Zealand is an example, with a strong institutional environment (Ministry of Foreign Affairs and Trade (New Zealand), 2023). This model builds trust with international partners and contributes to the stability of foreign trade relations. At the same time, the EU Single Market legal framework enables a coordinated response to supply disruptions, allowing member states to act in a coordinated manner in the face of crisis challenges.

A flexible and skilled labor is one of the key prerequisites for economic and trade resilience. The ability of the labor force to quickly adapt to changes in the structure of demand, technological transformations and external shocks ensures the continuity of production and trade processes. An example is Germany, where the system of vocational education and dual training model allows for rapid reorientation of workers between sectors of the economy, mitigating the effects of fluctuations in export markets (Haasler, 2020).

Agile trade policies and crisis response are important mechanisms for reducing the negative impact of external shocks on the economy. Rapid adaptation of trade rules, tariff regimes and customs procedures allows minimizing supply disruptions and maintaining the competitiveness of exporters. One example is Vietnam, which during the COVID-19 pandemic quickly eased restrictions and adapted customs protocols, which allowed to maintain export flows and attract investments in re-shoring projects.

Stable Economy ensures the rise of trade resilience. Macroeconomic stability supports investor confidence, provides predictability for business, and creates conditions for the economy to adapt quickly to external shocks. A good example is Switzerland, where stable fiscal policies and disciplined monetary independence have historically supported investment confidence and trade (International Monetary Fund, 2024). Countries with high levels of foreign exchange reserves and low public debt-to-GDP ratios are able to implement countercyclical measures without significant negative market reactions, which further increases their resilience to external shocks.

Access to multiple trade routes implies the existence of diversified transport corridors, which allows for rapid re-routing of trade flows in the event of disruptions, reducing dependence on a single route and minimizing the risks of logistical delays. A relevant example is the Netherlands, where the Port of Rotterdam, combined with an integrated European logistics network, ensures the resilience of trade flows and reduces the risks of concentration on individual routes (European Environment Agency, n. d.).

Robust domestic demand provides an alternative to export markets and supports employment and production even in conditions of reduced global demand. An example is China, which during the trade war with the US increased domestic consumption and investment, which allowed it to partially compensate for the reduction in external demand and mitigate economic losses (Zhao, 2025).

2. Resilience of regional trade clusters

The Global Trade Resilience Index (GTRI) is a flagship initiative developed by Whiteshield, an international strategic development and public policy consultancy, in collaboration with experts from Harvard University and the OECD. GTRI was launched in 2023 as a strategic analytical tool to support countries in strengthening their trade integration while reducing their vulnerability to external shocks (Whiteshield Partners, 2025b)

Unlike traditional indices that mostly capture current trade activity, GTRI uses the tools of complex network theory and scenario modeling to assess the potential behavior of countries under different types of trade disruptions. Structurally, GTRI measures trade resilience in two key areas:

Absorptive Capacity. This component reflects the country's ability to withstand the immediate impact of external shocks while maintaining relative stability of trade operations at the initial stage of destabilization. It concerns the structural diversification of trade flows, centrality in global networks, the availability of alternative trade partners, as well as the quality of institutions and infrastructure that ensure a prompt response to risks.

Recovery Capacity. This component characterizes the ability of the state to restore trade activity and adapt to changed conditions in the short and medium term after the onset of a shock. It covers the flexibility of the economic structure, innovation potential, the effectiveness of government policies and the ability to reorient supply chains.

The methodological basis of GTRI involves a comprehensive assessment of the ability of national economies to absorb, adapt and recover from trade shocks. The index integrates indicators of the network structure of international trade (in particular, the level of centrality in global value chains, significance in world flows and the degree of diversification of trading partners), as well as indicators of institutional quality, operational efficiency and infrastructure development. Thus, the GTRI combines structural parameters of foreign economic integration with characteristics of domestic economic capacity. In 2025, the GTRI was calculated for

132 countries of the world, which provides representative coverage of the global trade system. In order to outline the main trends and identify leading countries in trade resilience, it is advisable to refer to the analysis of the positions of the top thirty of the rating (*Figure 1*).

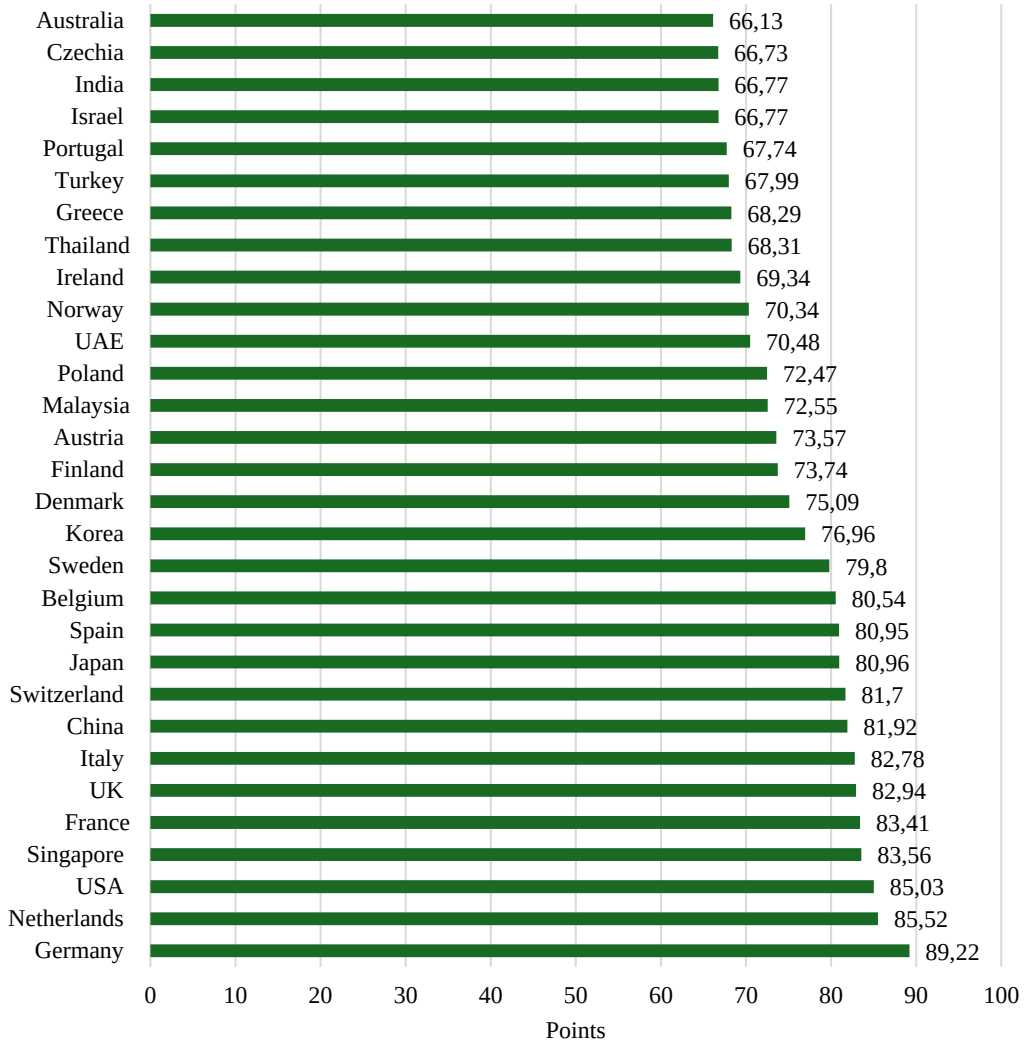


Figure 1. Top 30 performers in the GTRI 2025.

Source: (Whiteshield Partners, 2025a).

The European region maintains its leading position at the top of the GTRI ranking, as 16 of the 30 countries are from Europe (Germany, the Netherlands, France, the United Kingdom, Italy, Switzerland, Spain, Belgium, Sweden, Denmark, Finland, Austria, Poland, Greece, Portugal, the Czech Republic, Ireland). This concentration reflects the region's leadership, which is due to a high level of intra-regional and global integration, a developed infrastructure base and stable institutions.

North America is represented in the top 30 only by the United States (3rd place). The region's relatively limited representation is explained by the smaller number of independently integrated economies and the high

concentration of trade flows within the USMCA, which makes it more vulnerable to internal shocks of individual partners.

East and Southeast Asia are represented by countries such as China, Japan, South Korea, Singapore, Malaysia and Thailand. Accordingly, this illustrates the region's strategic importance as a hub for manufacturing and technology networks, providing high network integration and operational efficiency.

Other regions include the Middle East (United Arab Emirates, Israel) and South Asia (India), which indicate a gradual increase in the trade resilience of economies with high growth potential. Australia (30th place) demonstrates the regional importance of Oceania in global trade networks.

In general, the top five countries in the ranking are Germany, the Netherlands, the United States, Singapore, and France. An analysis of their positions suggests a common model for ensuring trade resilience, based on a combination of several complementary factors:

- high-quality transport, logistics, and digital infrastructure;
- effective public administration institutions and a stable regulatory environment;
- significant innovation potential and technological capabilities;
- deep integration into global and regional production networks.

It is important to note that the leadership of these countries is not limited solely to the size of their economies or export volumes. Instead, it reflects the systemic nature of their competitiveness, where institutional quality, infrastructure, and network positioning mutually reinforce each other.

At the regional level, countries can be aggregated into four relatively homogeneous clusters based on their GTRI scores (*Figure 2*). Despite significant differences between clusters, within each group, countries exhibit relatively similar levels of trade resilience: North America and Europe; Middle East and North Africa (MENA) and East Asia and the Pacific; Central Asia, South Asia and Latin America and the Caribbean; Sub-Saharan Africa.

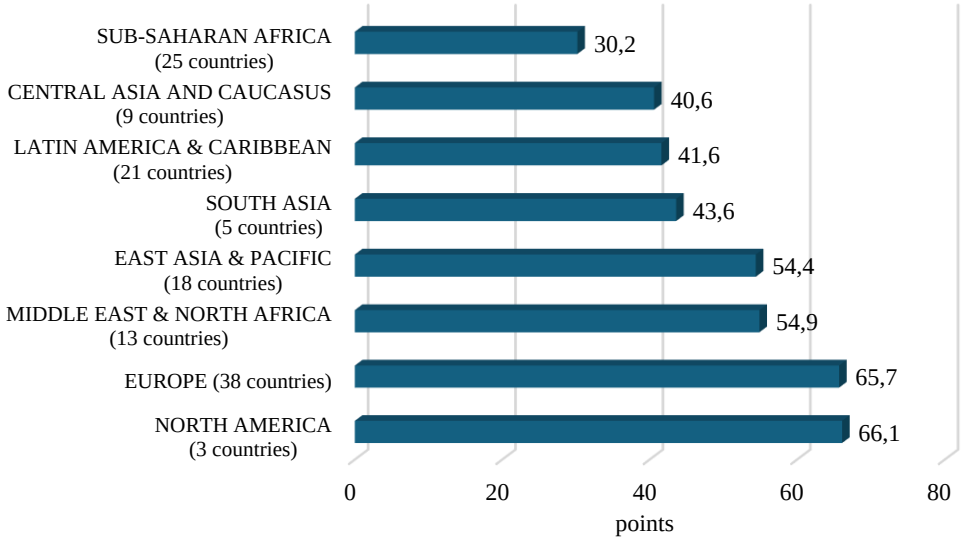


Figure 2. Regional GTRI in 2025 performance

Source: (Whiteshield Partners, 2025a).

North America shows the highest level of trade resilience. The decisive role in this is played by the economic power of the United States, which accumulates about 14% of world imports and ranks third in the global GTRI ranking. In contrast, Canada (45th place) and Mexico (58th place) are characterized by a significantly lower level of resilience compared to the United States.

Europe generally shows a level of trade resilience comparable to North America, but the regional average hides significant internal differentiation. Almost half of European countries are in the top 30 of the global ranking. At the same time, eight of the ten lowest-ranked European countries are located in Eastern Europe, including belarus, Moldova and Albania. These countries are characterized by limited international trade integration, weaker institutional governance mechanisms and underdeveloped infrastructure, which increases their vulnerability to external shocks. Therefore, the use of aggregated regional indicators can mask local structural imbalances, which necessitates a targeted policy to increase trade resilience in structurally weaker areas of Europe.

The second cluster is formed by East Asia and the Pacific, together with the MENA countries, which show significantly lower results compared to the leaders. In East Asia and the Pacific, 7 out of 17 countries are in the top 30, but at the same time three countries have positions below 100th place, which indicates significant inter-country differentiation. In the MENA region, the distribution of indicators is more even, from 20th place, which is occupied by the United Arab Emirates, to 83rd place by Lebanon. In South Asia, the regional leader is India (28th place), while other countries lag significantly behind in terms of trade resilience. A similar situation is observed in Central Asia, where Turkey (25th place) significantly outperforms other countries in the region. In Latin America and the Caribbean, only five out of 22 countries rank in the top half of the ranking, indicating the region’s limited ability to adapt to global trade turbulence.

The lowest scores are recorded in sub-Saharan Africa, which forms the least trade-resilient cluster. Only South Africa (39th) ranks in the top half of the global ranking. Most other countries in the region rank outside the top 100, reflecting systemic challenges in trade infrastructure, institutional capacity, and global positioning.

Thus, the GTRI regional analysis confirms the existence of a clearly defined hierarchy of trade resilience in the global economy, and also reveals significant intra-regional asymmetries that need to be taken into account when formulating policies to ensure economic resilience and trade resilience to external shocks.

3. Regional impact of the "US trade shock"

Given the growing role of the US in the global trade and financial system, a potential economic shock in the US has a distinct regional dimension and can affect countries around the world differently depending

on their level of integration into US-centric value chains. The degree of dependence on the US market, the structure of exports, the nature of trade flows and the depth of intra-regional cooperation determine how vulnerable or, conversely, resilient regions are to such a shock.

The essence of the "US shock" lies in sudden or significant changes in economic policy, financial conditions or macroeconomic dynamics that have a systemic impact on the world economy due to the high level of US global integration. Such a shock can manifest itself in several dimensions:

The trade dimension is the introduction of protectionist measures (increasing tariffs, quotas, sanctions), revising trade agreements or restricting access to the US market. Accordingly, this directly affects countries whose exports are largely oriented towards the United States.

The financial dimension is a sharp change in monetary policy (for example, an increase in interest rates by the Federal Reserve), which causes capital outflows from developing countries, a strengthening of the dollar and an increase in the cost of servicing external debt.

The demand-cyclical dimension is an economic recession in the United States, which reduces global demand for goods and services, affecting global value chains.

The geopolitical dimension is a change in foreign economic or sanctions policy, which transforms trade routes and the structure of international economic relations.

Thus, the essence of the shock lies not only in the negative impact on the US economy itself, but in its transmission through trade, financial and institutional channels to other regions. The degree of impact is determined by the depth of a country's integration into US-centric supply chains, its dependence on the dollar as a reserve currency and the structure of its foreign trade.

Countries with higher absorptive capacity tend to be better prepared to counter targeted trade policy shocks, in particular sudden tariff increases or the introduction of other protectionist measures. To explore this relationship, we compared the GTRI absorptive capacity indicators with the Whiteshield platform forecasts (Trade Navigator tool), which estimate the expected changes in exports for 20 of the US's top trading partners under a scenario of full implementation of the reciprocal tariffs announced by the US, together with the expected retaliatory measures from trading partners.

The GTRI Index and Trade Navigator provide complementary approaches to assessing trade resilience. GTRI analyzes a country's structural positioning within 96 commodity-specific global trade networks, focusing on the extent of its integration and diversification of trade across products and partners. Trade Navigator, in turn, combines country-specific tariff rate data with trade elasticity measures to model the likely response of trade flows to changes in trade policy, including the introduction of new tariffs or countermeasures. Combining GTRI's structural approach with Trade Navigator's policy-sensitive modeling provides a more comprehensive

and multidimensional understanding of both the long-term resilience and short-term vulnerability of countries to changes in U.S. trade policy. As shown in *Figure 3*, U.S. trading partners can be roughly divided into three groups based on their level of resilience and projected impact on trade.

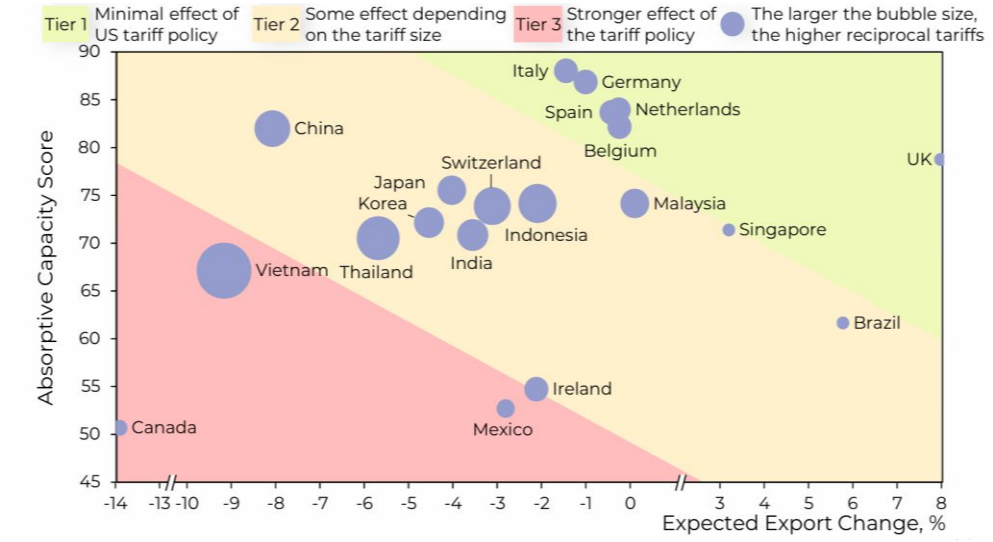


Figure 3. Countries' absorptive capacity vs. expected trade impact from U.S. reciprocal and reetaliation tariffs for top 20 U.S. trade partners

Source: (Whiteshield Partners, 2025a).

Tier 1 includes countries that are expected to experience minimal disruption to trade flows from new tariffs. These economies combine high absorptive capacity with low to moderate levels of reciprocal tariffs, resulting in little projected change in trade volumes. A good example is the United Kingdom, which demonstrates a high level of structural adaptability and can at the same time benefit from relatively low tariffs by increasing its market share at the expense of less resilient partners. This group also includes leading European economies, such as Germany and the Netherlands, which are characterized by exceptional structural resilience. Singapore is also in Tier 1, and despite only moderate absorptive capacity, its relatively low tariff rate (10%) allows it to withstand the shock relatively well. Tier 2 consists of countries that are moderately affected by US tariffs. They are characterized by higher tariff rates combined with moderate levels of absorptive capacity. This group mainly includes East and South Asian economies, including China, South Korea, Japan, India and Indonesia. While these countries may face significant trade losses, their structural resilience partially mitigates the magnitude of the shock.

Tier 3 covers the most vulnerable countries, characterized by either high trade dependence on the United States, low absorptive capacity, or a combination of both. Canada and Mexico are particularly vulnerable due to their concentrated orientation towards the US market, even despite moderate tariffs. Vietnam suffers from the double negative effect of a high tariff

burden and only moderate absorptive capacity. Ireland is on the edge of this group and may suffer primarily due to its relatively low structural adaptability, even if its tariff rates are not at their maximum.

Although the GTRI methodology does not directly account for tariff differentiation between countries, there is a moderate correlation between absorptive capacity and the projected impact on exports. Over 0.3 for the full sample and over 0.5 for the top ten US trading partners. Accordingly, this suggests that higher absorptive capacity is generally associated with lower expected export losses.

At the same time, the variability of tariff rates partially weakens this relationship. Under the condition of modeling a unified shock (without inter-country tariff differences), the correlation coefficient increases to 0.6, which further confirms the significant role of structural stability in mitigating the consequences of trade policy changes.

Thus, the "US trade shock" acts as a stress test for the global economic system, revealing not only the current dependence of countries on the US market, but also the deep structural characteristics of their trade model. Regional trade resilience in this context is determined not only by the scale of tariff impact, but primarily by the ability of economies to diversify, adapt, and quickly restructure trade relations.

Conclusions

The modern global trade system is in a phase of profound transformation, characterized by increasing uncertainty, market fragmentation, and increased strategic competition between countries. Escalation of tariff restrictions, disruption of supply chains due to the pandemic, climate instability, and the use of critical technologies as a tool of geoeconomic influence have shown that shocks have become not episodic phenomena, but a systemic feature of global trade. Under such conditions, the trade resilience is transformed from a desirable characteristic into a key factor in ensuring national competitiveness.

The study has made it possible to empirically confirm the hypothesis put forward regarding the key determinants of the trade resilience. The results obtained indicate that regional clusters with a high level of diversification of trade relations demonstrate less vulnerability to external shocks and faster adaptation to changes in the world markets. Deeper integration into global and regional production networks provides a risk-sharing effect and supports the continuity of value chains even under trade restrictions. At the same time, the quality of the institutional environment acts as a system-forming factor that enhances adaptability, predictability and coordination of economic processes within clusters.

The analysis of the scenario of an isolationist tariff policy by the United States indicates significant regional differentiation of impacts. European countries incur the lowest losses, which can be explained by their

high absorptive capacity and relatively low level of reciprocal tariffs imposed by the United States. The combination of a diversified trade structure and well-developed intra-regional cooperation creates an additional resilience buffer for Europe.

In contrast, Mexico, Canada and Vietnam demonstrate higher vulnerability. For Mexico and Canada, the key risk factor is limited absorptive capacity combined with high dependence on the American market. Vietnam, in turn, faces one of the highest levels of reciprocal tariffs, which amplifies the negative effect.

East Asian and MENA economies, in particular Singapore, South Korea, and the United Arab Emirates, appear to be more sensitive to a US isolation scenario, despite their generally high level of trade resilience. Their deep integration into US-oriented supply chains increases the risk of losses in the event of sharp changes in trade policy.

Thus, the findings of the study confirm that the resilience of regional trade clusters is shaped by structural, integration, and institutional factors. Ensuring this resilience requires policies aimed at diversifying trade flows, deepening integration into production networks, and strengthening institutional capacity. Further research should focus on developing dynamic and multi-level approaches to analyzing trade resilience, including deeper sectoral disaggregation, and the assessment of technological and digital factors influencing global value chains, while also expanding the geographical scope to include economies undergoing structural transformation and post-crisis recovery, in order to better understand the interaction between trade resilience and broader dimensions of economic resilience.

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STRUCTURAL TRANSFORMATIONS OF UKRAINIAN EXPORTS

The article examines the structural transformation of Ukraine's exports under the impact of the full-scale war of 2022, which triggered an unprecedented shock to the country's trade system. The relevance of the study stems from the profound shifts in logistical, institutional, and production conditions that reshaped external trade flows and generated a critical dependence on the European Union market. The research is based on the hypothesis that the war caused not temporary fluctuations but a deep and irreversible structural reconfiguration of Ukraine's export model, reflected in changes in geographical orientation, commodity composition, and market concentration. The methodological framework includes: comparative analysis of export dynamics in 2010–2024; calculation of the Herfindahl-Hirschman Index (HHI) to assess geographic concentration; graphical modeling of long-term trends; identification of factors influencing the war on the export of goods from Ukraine. The statistical database was compiled based on data from the State Statistics Service of Ukraine, the European Commission, UN Comtrade, analytical reports from international organizations (Oxfam, Deloitte, PricewaterhouseCoopers, Brookings Institution, Statista), and author calculations. The results substantiate the proposed hypothesis. The share of exports directed to the EU increased from 24% in 2010 to over 60–66% in 2022–2024, while exports to Asia and Africa contracted sharply due to the blockade of Black Sea ports. The commodity structure shifted from metallurgy to agriculture. Export concentration reached record levels (HHI ≈ 0.48 in 2023). The study identifies key adaptive mechanisms, including the expansion of Danube

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СТРУКТУРНІ ТРАНСФОРМАЦІЇ ЕКСПОРТУ УКРАЇНИ

Проаналізовано структурну трансформацію українського експорту, зумовлену повномасштабною війною 2022 р., що стало безпрецедентним шоком для торговельної системи України. Актуальність дослідження викликана різкою зміною логістичних, інституційних і виробничих умов, що визначили нову конфігурацію зовнішньоторговельних потоків та сформували критичну залежність від ринків Європейського Союзу. Внесено гіпотезу, що війна спричинила не короткострокові коливання, а глибоку та незворотну структурну перебудову експорту, яка проявляється у зміні його географічної орієнтації, товарної структури та рівня ринкової концентрації. Методологія дослідження включає: порівняльний аналіз динаміки експорту у 2010–2024 рр.; розрахунок індексу географічної концентрації Herfindahl-Hirschman Index (HHI); графічне моделювання довгострокових трендів; ідентифікацію факторів впливу війни на експорт товарів з України. Статистичну базу сформовано на основі даних Державної служби статистики України, Єврокомісії, UN Comtrade, аналітичних звітів міжнародних організацій (Oxfam, Deloitte, Pricewaterhouse-Coopers, Brookings Institution, Statista) та авторських розрахунків. Отримані результати підтверджують гіпотезу дослідження. Встановлено, що частка експорту до ЄС зросла з 24% у 2010 р. до понад 60–66% у 2022–2024 рр., тоді як обсяги експорту до Азії та Африки різко скоротилися через блокаду морських портів. Товарна структура зазнала зсуву від металургії до аграрної продукції; рівень географічної концентрації експорту досяг рекордних значень (HHI ≈ 0.48 у 2023 р.).

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logistics routes, deepening integration with the EU, and digitalization of customs procedures. The findings confirm that Ukraine's export sector is undergoing a systemic and irreversible transformation that will shape the trajectory of post-war recovery and long-term integration into European and global markets.

Keywords: Ukraine's exports, export structure, EU, logistics, war, geographical concentration, Herfindahl–Hirschman Index, foreign trade.

Виявлено ключові адаптивні механізми – розвиток дунайських маршрутів, поглиблення інтеграції з ЄС, цифровізація митних процедур. Дослідження підтверджує, що експорт України перебуває у фазі системної трансформації, яка визначатиме траєкторію післявоєнної відбудови та інтеграції в європейські ринки.

Ключові слова: експорт України, структура експорту, ЄС, логістика, війна, географічна концентрація, *Herfindahl–Hirschman Index*, зовнішня торгівля.

JEL Classification: F14, F15, F51.

Introduction

Structural transformations in exports are an integral component of long-term economic development and macroeconomic resilience in a globalised economy. Many countries face the need to adapt their production structures and foreign trade sectors to changes in technological paradigms, intensifying global competition, shifts in demand in world markets, and growing geoeconomic and geopolitical risks. The drivers of such transformations are diverse, ranging from technological innovation and the green transition to crises, pandemics, and armed conflicts, all of which affect national specialisation patterns in different ways.

For Ukraine, the issue of structural changes in exports has become particularly acute. In 2010–2024, foreign trade development was influenced by a number of major external shocks, including global economic crises, the COVID-19 pandemic, and the full-scale military invasion of the russian federation in 2022. The war became a catalyst for profound structural shifts, causing the destruction of production capacity, the blockade of port infrastructure, the disruption of traditional logistics chains, and a sharp decline in investment activity. As a result, these processes not only transformed export volumes but also significantly altered their commodity and geographical structure.

The problem is that contemporary structural transformations in Ukraine's exports are not merely situational but also long-term in nature, shaping new parameters of the country's economic model. The strengthening of agrarian and resource-based specialisation, the narrowing of production diversification, the increasing concentration of export markets, limited access to maritime logistics, and greater dependence on EU institutional and trade support create a complex set of systemic risks. This highlights the need for a comprehensive scientific analysis of structural shifts in Ukraine's exports, the identification of their causes and consequences, and the development of approaches to enhancing the resilience and adaptability of the foreign trade system amid prolonged instability.

The aim of this article is to assess the transformations in Ukraine's exports in 2010–2024, driven by a combination of technological, institutional,

logistical, and geopolitical factors, as well as by the specific manifestations of these processes under conditions of full-scale war. Particular attention is paid to identifying changes in the commodity and geographical structure of exports, the level of export market concentration, and the role of war-related and logistical shocks in shaping the current dynamics of Ukraine's exports.

To achieve this aim, the following objectives have been set: to analyse the stages of development of Ukraine's exports in 2010–2024 and identify the key patterns in their dynamics; to systematise structural shifts in the commodity and geographical structure of exports; to assess the level and dynamics of export concentration using the Herfindahl-Hirschman Index; to identify the impact of the main institutional, logistical, production, and security factors associated with the war on export processes; and to synthesise the findings of the analysis in order to develop an analytical model of transformations in Ukraine's exports under conditions of high uncertainty.

The study is based on the hypothesis that the full-scale war constituted a major exogenous shock that significantly intensified and accelerated the existing trends in structural changes in Ukraine's exports, particularly in terms of commodity specialisation and geographical orientation. At the same time, the structural shifts observed in 2022–2024 may be either temporary or potentially more persistent in nature, which requires empirical verification.

A significant contribution to the study of transformations in Ukraine's foreign trade has been made by Ukrainian scholars who have analysed both long-term trends in export development and the impact of crises and war-related factors on export dynamics and geographical structure. In particular, Mazaraki and Melnyk (2025) examined the influence of institutional and logistical factors on the formation of Ukraine's current export model. The authors emphasise that hostilities have significantly accelerated the reorientation of trade flows, brought the issue of adapting customs and transport infrastructure to the forefront, and increased the dependence of exports on European markets.

The geoeconomic transformations of the global economy in the twenty-first century were examined by Herasymenko (2020), with a focus on the interaction between globalisation, regionalisation, and economic resilience. The author argues that contemporary geoeconomic development is characterised by a combination of dynamic changes and structural stability, creating new challenges for national economies.

Halutskykh and Koshkarova (2022) investigated the evolution of Ukraine's foreign trade model amid global instability and European integration processes. The authors focus on the gradual increase in the role of the European Union as a key trading partner while also highlighting the risks associated with excessive concentration of export flows. Their analysis of structural changes in exports by commodity group and regional destination is particularly valuable, as it makes it possible to identify vulnerable segments of Ukraine's foreign trade.

Boichyk (2023) analyses the role of market infrastructure in ensuring the stability and adaptability of Ukraine's business sector under martial law, emphasising the importance of its functional components in supporting small and medium-sized enterprises during periods of crisis-driven transformation.

The impact of armed conflicts, logistical shocks, and institutional changes on international trade has been addressed in the works of foreign researchers. Their focus is on the transformation of trade flows, increasing regional concentration, and the adaptive mechanisms employed by economies under crisis conditions. In particular, Gnangnon (2020) examines the impact of international trade cooperation and multilateral trade liberalisation mechanisms on reducing the magnitude of exogenous economic shocks in developing countries. The author demonstrates that participation in global trade institutions, particularly within the framework of the WTO and the "Aid for Trade" programme, helps mitigate the adverse effects of external shocks on trade flows and reduces their magnitude.

The reports by the OECD (2024) and the World Bank (2024) examine structural shifts in Ukraine's foreign trade since 2022, focusing on logistical constraints, the blockade of maritime routes, and the reorientation of exports towards European overland corridors. These studies confirm that war acts as a catalyst for long-term changes in the trade model rather than merely constituting a temporary shock.

Analytical materials published by Deloitte (2024) and PricewaterhouseCoopers (2024) focus on the transformation of global supply chains and the growing importance of trade regionalisation. The authors emphasise that countries facing war-related risks are compelled to rapidly adapt their export logistics and place greater emphasis on integration with nearby stable markets. Research by the Bruegel Institute (2024) and Statista (2024) further contributes to the academic debate by providing empirical assessments of trade flow concentration and changes in the commodity structure of exports amid geopolitical instability. Their findings are consistent with the results of this article regarding the increasing geographical concentration of exports and the heightened systemic risks to export resilience.

The information base comprises statistical data from the State Statistics Service of Ukraine, the State Customs Service of Ukraine, the European Commission, and UN Comtrade, as well as analytical reports by international organisations (Oxfam, Deloitte, PricewaterhouseCoopers, the Brookings Institution, Statista). The data were processed by constructing time series, calculating concentration indicators, conducting structural analysis, and performing factor decomposition. The limitations of the study are attributable to the partial lack of complete data for certain commodity groups after 2022, uneven access to logistics statistics, and methodological differences between international statistical systems.

Structurally, the article consists of four sections. The first examines the stages and dynamics of Ukraine's export development in 2010-2024. The second section presents a periodisation of the key changes in Ukraine's merchandise exports. The third section analyses the level of export concentration and identifies the key structural shifts. The fourth section identifies the main groups of factors – institutional, logistical, energy-related, financial, security-related, social and labour-related, environmental, and production-structural – that determine the transformation of foreign trade flows, based on an assessment of the factors through which the war has affected Ukraine's merchandise exports.

The study is expected to identify the key mechanisms through which structural transformations affect the dynamics and resilience of Ukrainian exports, clarify the role of war-related, logistical, institutional, and market factors in shaping the current export model, and determine long-term trends in changes in commodity and geographical specialisation. The findings are intended to provide a basis for developing practical recommendations aimed at enhancing the competitiveness of Ukrainian exports, reducing the risks associated with excessive market concentration, establishing effective mechanisms for adapting to external shocks, and strengthening Ukraine's integration into global trade chains. They may also be used to improve state trade policy, strategic planning, and the development of support instruments for export-oriented sectors of the economy amid prolonged external challenges.

1. Dynamics and stages of Ukraine's export development in 2010–2024

The war has constituted an unprecedented shock to Ukraine's trading system. Before 2022, foreign trade accounted for more than 40% of GDP, and Ukrainian exports were deeply integrated into international markets. Dependence on Black Sea ports, a high share of raw materials in exports, and infrastructural vulnerability created conditions in which hostilities immediately disrupted supply chains (World Bank, 2024).

In 2022, Ukrainian ports, through which more than 60% of exports passed, were blockaded. The destruction of industrial facilities, logistical constraints, congestion along rail and road corridors, and the loss of market share in the Middle East and Asia all created a critical need to assess the resilience of the export system and its ability to adapt (OECD, 2025).

The dynamics of Ukrainian exports in 2010–2024 (Table 1) demonstrate a succession of profound structural transformations caused by both external economic factors and a series of crisis shocks. These include the annexation of Crimea in 2014, the armed conflict in Donbas, the COVID-19 pandemic, and russia's full-scale invasion in 2022.

Table 1

Volume of Merchandise Exports from Ukraine in 2010–2024*, USD million

Year	Total	CIS countries	Other countries of the world	Europe	EU countries (27)	Asia	Africa	America	Australia and Oceania
2010	51405.2	18740.6	32664.6	13829.6	12411.9	13715.4	3018.7	2000.0	28.4
2011	68394.2	26177.0	42217.2	18442.4	17378.0	17737.8	3344.2	2552.3	29.8
2012	68830.4	25318.6	43511.8	17424.0	16410.8	17681.1	5638.2	2607.7	50.9
2013	63320.7	22077.3	41243.4	17064.2	16048.4	16813.0	5094.7	2163.6	40.1
2014	53901.7	14882.3	39019.4	17122.1	16413.7	15350.9	5098.2	1372.2	23.5
2015	38127.1	7806.1	30321.0	13248.3	12647.3	12378.9	3803.3	785.6	13.6
2016	36361.7	6031.5	30330.2	13790.1	13178.5	11796.3	3865.1	735.2	18.3
2017	43264.7	6916.4	36348.3	17901.9	17053.4	12967.3	4047.7	1207.9	71.9
2018	47335.0	7025.2	40309.8	20606.0	19572.8	13754.1	4127.0	1620.0	48.6
2019	50054.6	–	–	26739.5	20122.7	16646.1	4971.5	1467.9	59.0
2020	49191.8	–	–	23736.1	17938.1	19699.0	4048.0	1548.9	67.1
2021	68072.3	–	–	34213.6	26793.0	24762.1	5626.8	3258.5	73.9
2022	44135.6	–	–	30271.7	27890.7	10467.7	2129.8	1190.6	29.0
2023	37584.3	–	–	25455.0	24715.9	8051.0	1678.1	760.1	21.5
2024	41733.3	–	–	26665.7	24829.8	10837.2	2943.2	1241.7	23.9

**Since 2019, the columns "CIS countries" and "Other countries of the world" have not been completed. For 2014–2024, the data are presented excluding the territories temporarily occupied by the Russian Federation and parts of the territories where hostilities are being (or have been) conducted.*

Source: State Statistics Service of Ukraine (2024).

The analysis of the data indicates that Ukraine's export system has undergone several stages: a period of growth (2010–2013), a transformation and crisis phase (2014–2016), recovery (2017–2021), and a new large-scale shock followed by adaptive changes (2022–2024) (Ministry of Economy of Ukraine, 2023).

In 2010–2012, Ukrainian exports grew steadily, from USD 51.4 billion to USD 68.8 billion, which was associated with strong global demand for metallurgical and agro-industrial products. However, in 2013, exports declined to USD 63.3 billion, reflecting the first signs of macroeconomic instability.

The outbreak of the armed conflict in eastern Ukraine in 2014 led to the sharpest decline in exports up to that point, with exports falling to USD 38.1 billion in 2015. This significant downturn was caused by the loss of industrial capacity in Donbas, the severing of cooperative ties with the Russian Federation, the reorientation of trade flows, and the devaluation of the hryvnia.

In 2017–2021, Ukrainian exports entered a phase of stabilisation and moderate growth, reaching USD 68 billion in 2021. This period was characterised by deeper integration with the European Union, the growing role of the agricultural sector, and the gradual recovery of metallurgical production.

Russia's full-scale invasion in 2022 once again caused a sharp decline in exports, to USD 44.1 billion, representing a 35% decrease compared with 2021. The main causes were the blockade of Black Sea ports, the destruction of logistics and industrial infrastructure, and restrictions on maritime routes,

which had traditionally accounted for more than 70% of Ukrainian exports. The decline continued in 2023, when exports amounted to USD 37.6 billion. However, 2024 showed signs of a partial recovery, with exports reaching USD 41.7 billion, indicating the emergence of new adaptive mechanisms.

In 2010–2013, the CIS countries accounted for 33–37% of Ukrainian exports, indicating a strong dependence on the russian market. After 2014, the share of this destination declined rapidly, and from 2019, official statistics ceased to identify the CIS as a separate category due to the effective loss of this market. Thus, over the decade, Ukraine's geoeconomic orientation underwent a complete transformation.

The EU became the main market for Ukrainian products. While the EU accounted for 24% of exports in 2010, its share had risen to more than 39% by 2021. In 2022–2024, following the blockade of maritime routes, the EU's importance increased further: 63% in 2022, 66% in 2023, and approximately 60% in 2024. This was driven by the introduction of EU "trade visa-free arrangements", access to European logistics infrastructure, and the diversification of export routes through overland corridors (European Commission, 2023).

Until 2021, Asia was one of Ukraine's key trading destinations, accounting for USD 16–18 billion in exports annually. However, in 2022–2023, export volumes fell by more than half. The main reason was the inability to maintain stable maritime shipments of grain and metals due to the destruction of Black Sea infrastructure and the risks to maritime navigation.

Exports to Africa and the Americas also declined, but less sharply, owing to the continued availability of certain logistics routes.

The wartime shock of 2022 caused the most radical changes in the structure and geographical distribution of Ukrainian exports in the entire history of Ukraine's independence. In this regard, several fundamental structural transformations can be identified:

- a reorientation of exports towards the EU market, which became the dominant export destination; for the first time throughout the period of independence, the EU's share exceeded two-thirds of total exports;
- a decline in the role of maritime logistics and an increase in the importance of overland corridors through Poland, Romania, and Slovakia;
- a collapse in exports of metals and ores, which had traditionally been major export commodities, as a result of the destruction of steelworks in Mariupol and the blockade of the Sea of Azov;
- an increase in the share of agricultural exports as the most mobile and adaptable segment of foreign trade;
- the development of new adaptive mechanisms, including the digitalisation of customs procedures, the expansion of the Danube logistics corridor, and the use of alternative routes through the Balkans.

The data for 2010–2024 indicate that Ukrainian exports are undergoing an irreversible structural transformation. The loss of the russian market did not lead to the catastrophic destruction of export potential; on the contrary, rapid integration into the European economic area and the diversification of trade flows took place.

At the same time, the war has created a number of critical risks, including dependence on EU logistics corridors, the vulnerability of maritime infrastructure, a shift in the commodity structure towards raw-material specialisation, and a decline in exports of high-tech products.

2. Periodisation of key changes in Ukraine's exports

The analysis of changes in Ukraine's exports (*Table 2*) indicates that, over the period under study, Ukrainian exports underwent three structural transformations: from a raw-material-oriented model dominated by the CIS to a Europe-oriented model and then to an adaptive wartime model.

Table 2

Periodisation of Key Changes in Ukraine's Merchandise Exports in 2010–2024

Year	Export volume, USD billion	Key changes	Main characteristics
Growth and Relative Stability in 2010–2013			
2010	51.4	Beginning of growth	Recovery following the global financial crisis; strong external demand for Ukrainian steel and grain
2011	68.4	Record growth (+33%)	Peak prices for metals and agricultural products; active trade with the CIS and Asia
2012	68.8	Stabilisation	Favourable market conditions continued; exports of iron ore and ferroalloys increased
2013	63.3	Beginning of decline	Political instability; declining global demand for metallurgical products
Deep Crisis and a Sharp Shift in Trade Geography in 2014–2016			
2014	53.9	Decline in exports to the CIS	Severance of economic ties with the russian Federation; political sanctions; temporary occupation of Crimea
2015	38.1	Largest decline (–29%) in the country's history	Loss of Donbas industrial regions; hryvnia devaluation; contraction in industrial production
2016	36.3	Stabilisation at a low level	Initial steps towards reorientation to the EU; reduced dependence on the CIS
Recovery, Diversification and Integration with the EU in 2017–2021			
2017	43.3	Export recovery	The EU–Ukraine Association Agreement began to produce results; the agricultural sector expanded
2018	47.3	Sustained growth	Ukraine strengthened its presence in EU markets; the metallurgical sector stabilised
2019	50.0	The EU became the main trading partner	The EU became the main trading partner
2020	49.1	Moderate decline	COVID-19 affected logistics; the agricultural sector ensured export resilience
2021	68.0	Highest level since 2012	High global prices for agricultural products and iron ore; growth in exports to Asia and the EU
The Wartime Shock and the New Export Model in 2022–2024			
2022	44.1	Sharp decline (–35%)	Full-scale invasion; blockade of the Black Sea; destruction of the metallurgical industry; restricted logistics routes
2023	37.6	Lowest level in 20 years	Prolonged blockade of ports; instability of the grain corridor; energy attacks by the russian Federation
2024	41.7	Partial recovery	Increased use of the Danube route; expansion of the EU's "customs visa-free regime"; stabilisation of agricultural exports

Source: compiled by the author using data from the State Statistics Service of Ukraine (2024).

The reorientation towards EU markets is the most significant change of the decade: in 2010, the EU accounted for 24% of exports, whereas in

2023–2024, its share exceeded 60–66%. The war in 2022 was the most powerful shock, compared with which even the crisis of 2014–2016 appears less extensive. Logistical factors became decisive: changes in routes, the use of Danube ports, overland corridors, and the optimisation of border crossing points. The export structure shifted from metals towards agricultural products. Despite the severe crisis, Ukrainian exports demonstrated adaptability, confirming their potential for rapid recovery after the end of the war. These transformations directly affected the level of geographical concentration of exports, which is examined below.

3. Geographical concentration of Ukraine's exports and changes under the influence of the war

To gain a deeper understanding of structural transformations in Ukraine's foreign trade, a graphical analysis of key trends across the main regions – the European Union (EU), Asia, Africa, the Americas, Australia and Oceania – was conducted for 2010–2024 (*Figure 1*). The visualisation makes it possible to clearly trace both long-term trends and sharp changes caused by wartime and economic shocks.

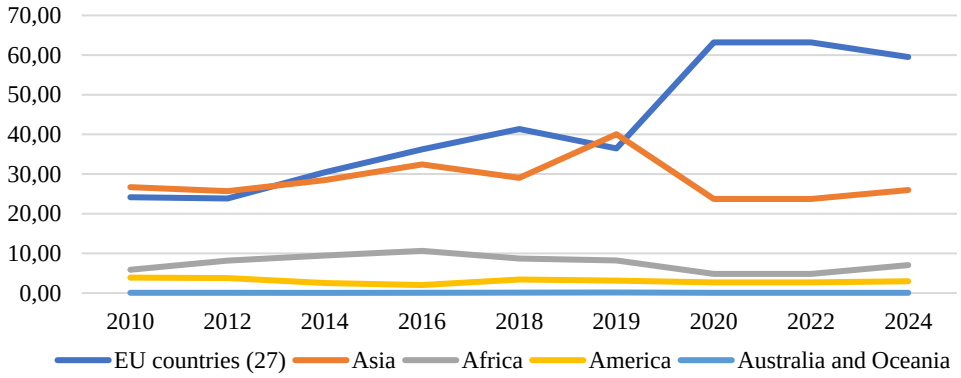


Figure 1. Geographical structure of Ukraine's merchandise exports, 2010–2024, %

Source: author's calculations based on data from the State Statistics Service of Ukraine (2024).

Based on the data in *Figure 1*, it is worth noting that the EU has consistently remained Ukraine's leading export destination throughout the entire period. In 2010–2014, the EU's share fluctuated within the range of 24–30%, without any sharp increases. After 2014, when the war began and part of Donbas's industrial capacity was lost, the EU's share increased moderately, reaching a peak in 2018 (over 41%). After 2021, a sharp increase is observed, reaching 63%, which was driven by the reorientation of exports under the conditions of russia's invasion in 2022. Due to the blockade of ports and changes in logistics, the EU effectively became almost the only gateway for Ukrainian goods to foreign markets. In 2023–2024, the EU's share declined slightly to 59.5%, but remained dominant. Thus, in 2022–2024, the EU effectively served as the "gateway" for Ukrainian exports, demonstrating critical dependence on European infrastructure and markets (United Nations, 2026; World Bank, 2024; OECD, 2025).

The Asian market maintained a high and stable share of Ukraine's export structure throughout 2010–2021. Moderate growth was observed in 2010–2015, while its peak was recorded in 2015–2018. In 2022, Asia's share in the geographical structure of Ukraine's merchandise exports declined, coinciding with the destruction of logistics infrastructure and restrictions on maritime transport. However, a partial recovery in supplies took place in 2023–2024. Thus, Asia remains a strategic market for Ukraine, although its share is heavily dependent on maritime infrastructure, which was partially blockaded in 2022–2023 (Center for Economic Strategy, 2023).

The share of Ukrainian exports to Africa increased almost twofold between 2010 and 2017, peaking in 2016–2017, as exports to African agricultural markets developed actively. After 2018, a gradual decline became apparent, particularly in 2022. In 2024, its share increased again. Thus, Africa can be characterised as a sensitive market that responds to logistical and security challenges, with the steepest decline associated with the period of port blockades.

The share of exports to the countries of the Americas remained below 4% throughout the period under study, reaching its peak in 2018. In 2021–2024, the figures stabilised at 2.7–3%. Consequently, the American market is not a key destination for Ukrainian exports; geographical distance and the commodity structure of exports limit its growth (Center for Economic Strategy, 2023).

The share of Australia and Oceania was close to zero in all the years under study. This region plays no structural role in Ukraine's overall exports (M. I. Dolishniy Institute of Regional Research of the National Academy of Sciences of Ukraine, 2022).

Therefore, the analysis of the geographical structure of Ukraine's exports illustrates its profound transformation, particularly after 2022. The EU has become the main and strategically critical market, while exports to Asia and Africa have been most severely affected by logistical constraints. In the long term, restoring the balance between the EU and Asia may indicate Ukraine's gradual return to a diversified pattern of trade relations.

Table 3

Herfindahl–Hirschman Index (HHI) for Ukraine's merchandise exports in 2010–2024

Level of concentration	Year	*HHI*
Low concentration (HHI: 0.13–0.14)	2010	0.134
	2011	0.136
	2012	0.131
	2013	0.142
Transition to moderate concentration (HHI: 0.18–0.26)	2014	0.183
	2015	0.226
	2016	0.248
	2017	0.255
	2018	0.264
Consistently moderate concentration (HHI: 0.28–0.30)	2019	0.283
	2020	0.301
	2021	0.296
Sharp increase in concentration, high level (HHI: 0.46–0.48)	2022	*0.459*
	2023	*0.481*
	2024	0.427

Source: author's calculations based on data from the State Statistics Service of Ukraine (2024).

The analysis of the data in *Table 3* indicates a clear long-term trend towards increasing geographical concentration of Ukraine's exports, pointing to a gradual narrowing of market diversification.

In 2010–2013, Ukraine's merchandise exports exhibited a low level of concentration. Until 2013, Ukrainian exports were relatively evenly distributed among the main markets – the EU, Asia, and, to some extent, the CIS countries (which were not included in this HHI calculation but nevertheless influenced the overall picture). The index remained within the low-concentration range, indicating a sufficient degree of diversification across trade destinations (World Trade Organization, 2023; Bruegel Institute, 2024).

During 2014–2018, Ukraine's merchandise exports transitioned towards moderate concentration. With the outbreak of the war and the decline in exports to the CIS, the structure shifted towards the EU and Asia, leading to a gradual increase in the HHI. The severance of production chains with the Russian Federation and the reorientation towards Western markets increased dependence on several key regions, reducing geographical balance.

In 2019–2021, Ukraine's merchandise exports exhibited a consistently moderate level of concentration. This period was characterised by relative macro-financial stability, but exports became more focused on the EU and Asia. The growth of agricultural exports to the EU strengthened dependence on one dominant market.

In 2022–2023, a sharp increase in the concentration of Ukraine's merchandise exports was recorded. Russia's full-scale invasion led to the blockade of seaports, the destruction of logistics routes, a decline in exports to Asia and Africa, and a sharp increase in the EU's share (to 63–66% of exports). This resulted in a record increase in the HHI to almost 0.50, corresponding to a high level of market concentration.

In 2024, the concentration of Ukraine's merchandise exports declined slightly, but the indicator remained high. The partial recovery of exports to Asia and Africa via Danube ports and alternative routes led to a moderate reduction in concentration; however, dependence on the EU remained above pre-crisis levels.

4. Identification of factors influencing Ukraine's merchandise exports during the war

The analysis conducted makes it possible to systematically assess the multidimensional impact of the full-scale war on the functioning of Ukraine's export sector and identify the key groups of factors determining the transformation of foreign trade flows in 2022–2025. The generalised results presented in *Figure 2* demonstrate that these changes are complex in nature, encompassing institutional, logistical, production and technological, financial, geoeconomic, regulatory, social and labour-related, and security dimensions.

Institutional	Logistical
"Customs visa-free regime" with the EU	Expansion of the capacity of Danube ports (Reni, Izmail, Kiliia)
Simplification of Ukrainian goods' access to the EU	Growing role of the Romanian port of Constanța
Liberalisation of road transport	Changes in rail logistics routes through Poland, Slovakia, and Hungary
Changes in certification rules and technical regulations	Implementation of the "Grain Corridor" without the participation of the Russian Federation (2023–2024)
Expansion of duty-free trade arrangements and preferential quotas	Rising costs of land transportation and customs clearance
Energy and Infrastructure	Financial and Currency-Related
Destruction of major metallurgical plants (Azovstal, Illich Iron and Steel Works)	Hryvnia volatility and the impact of foreign exchange interventions by the National Bank of Ukraine
Impact of attacks on the energy system on industrial production	Rising production costs due to inflationary shocks
Power supply disruptions and rising energy costs for enterprises	Shortages of working capital and higher borrowing costs
Damage to transport and warehousing infrastructure	Government compensation and lending programmes, 5–7–9% loans, and support for business relocation
Institutional and Security-Related	Social and Labour-Related
Military risks to trade routes	Labour migration and demographic losses
Blockade and restrictions affecting seaports	Shortages of skilled workers in industrial sectors
Rising costs of insuring cargo, vessels, and transport operations	Mobilisation processes and reduced workforce availability
Capacity constraints at EU border crossings (transport operators' protests and suspension of operations at border crossing points)	Social adaptation of enterprises that have relocated their production facilities
Territorial losses of production capacity	
Environmental and Climate-Related	Legal and Regulatory
Land degradation and territorial pollution resulting from military operations	Harmonisation of Ukrainian legislation with EU law
Higher costs of environmental certification of products for EU markets	Changes in the conditions of access to the EU market within the framework of pre-accession integration
More stringent environmental standards in international trade (CBAM)	New requirements for supply chain transparency (Due Diligence)
Marketing and Communications-Related	Production and Structural
Changes in the positioning of Ukrainian products in global markets	Changes in the structure of the economy towards the agricultural and food sectors
Growing importance of the "Made in Ukraine" brand in EU countries	Declining share of metallurgy and mechanical engineering in exports
Development of trade representative offices and participation in international exhibitions	Development of small and medium-sized enterprises as a driver of exports during wartime

Figure 2. Factors Influencing Ukraine's Merchandise Exports during the War

Source: compiled by the author.

Institutional factors have been a fundamental driver of the reorientation of Ukrainian exports towards European Union markets. The introduction of the "customs visa-free regime", the liberalisation of road transport, the harmonisation of technical regulations, and the simplification of access for products to the EU internal market have significantly accelerated

Ukraine's integration into European supply chains. These measures have not only compensated for the loss of access to traditional Asian and post-Soviet markets but have also created an institutional foundation for long-term trade and economic integration.

Logistical factors have determined critical constraints while simultaneously acting as a stimulus for structural changes in exports. The blockade of major Black Sea ports has led to the reorientation of trade flows towards Danube ports (Reni, Izmail, Kiliia), intensified cooperation with the port of Constanța, and increased rail freight volumes through Central European countries. At the same time, the establishment of an alternative "Grain Corridor" in 2023–2024 without the participation of the Russian Federation opened up new routes for exporting agricultural products, although these remain more expensive and less predictable than pre-war maritime transport.

Energy and infrastructure factors have also been significant, causing a substantial decline in the export potential of certain sectors. Extensive destruction of metallurgical plants in eastern Ukraine (in particular, Azovstal and Illich Iron and Steel Works), along with regular attacks on the energy system, has led to lower production and higher production costs. This has directly affected the structure of exports, increasing the share of agricultural products while reducing the share of the metallurgical segment and high-value-added goods.

Financial and currency-related factors, among which exchange rate fluctuations, inflationary shocks, higher borrowing costs, and limited working capital for enterprises have been decisive, have also had a significant impact on the economy and trade. At the same time, government business support instruments (in particular, the "5–7–9%" programme) have partially mitigated these risks, helping to maintain export activity among small and medium-sized enterprises.

The group of *institutional and security-related factors* is also important, encompassing the direct impact of military risks on logistics chains, higher cargo insurance costs, and reduced predictability of trade operations. Port closures, periodic blockades at the EU border, and risks to transport infrastructure significantly constrain the physical capacity to increase exports.

Social and labour-related, *environmental and climate-related*, *marketing*, *and production and structural factors* provide a deeper understanding of how the war is transforming not only export volumes but also the very operating logic of export-oriented sectors. In particular, the relocation of enterprises is stimulating the modernisation of production lines; emigration and mobilisation are changing labour availability; EU environmental standards are making access to the European market more challenging for products; and the growing importance of the "*Made in Ukraine*" brand is shaping a new marketing strategy for product promotion.

Thus, the structure of factors demonstrates that the war has created a synergistic impact of different groups of factors, which simultaneously constrain export opportunities and open up new pathways for Ukraine's integration into global markets. Taken together, these factors are shaping a

new configuration of Ukraine's foreign trade policy, determining its strategic adaptation under conditions of high turbulence and increased risks.

The results obtained indicate a profound transformation of the geographical and commodity structure of Ukraine's exports under wartime conditions; however, their interpretation requires broader contextual understanding. The changes identified should not be viewed solely as a loss of export potential or a simplification of the structure of foreign trade; rather, they reflect a change in the forms, channels, and spatial organisation of Ukraine's participation in global markets.

The decline in the share of metallurgical products in merchandise exports, which at first glance may be interpreted as a loss of Ukraine's position in the global steel market, has a more complex nature. The destruction of production facilities in Mariupol and the blockade of the Sea of Azov have indeed led to a sharp reduction in the physical volume of metal exports. At the same time, these processes have been accompanied by increased investment activity by Ukrainian metallurgical companies abroad, particularly through asset acquisitions, participation in joint ventures, and integration into production chains in EU and Middle Eastern countries. Thus, part of the export potential of the metallurgical business is being transformed from a commodity-based presence into an investment and corporate presence, making it more difficult to interpret the decline in exports directly as a definitive loss of competitive positions.

A similar pattern can be observed in the agricultural sector, which became a key driver of export adaptation in 2022–2024. The increasing share of agricultural products in exports reflects their relative mobility, the speed with which logistics can be reconfigured, and their lower capital intensity compared with industrial sectors. However, this specialisation entails significant structural risks. The high concentration of agricultural exports in the EU market intensifies competition with European producers, which is already manifesting itself in trade disputes, temporary restrictions, and tighter regulatory barriers. In this context, the increase in the geographical concentration of exports, as recorded by the *Herfindahl–Hirschman Index*, is not merely an indicator of adaptation but also a signal of heightened vulnerability to the political and regulatory decisions of a key trading partner.

The identified concentration of exports towards the European market also reflects a deeper contradiction between the strategic need for sectoral and technological modernisation of exports and the severe geospatial constraints imposed by the war. On the one hand, integration with the EU encourages higher standards of quality, environmental sustainability, and production traceability, which are prerequisites for the transition to higher-value-added exports. On the other hand, logistical dependence on overland corridors, high transportation costs, and limited infrastructure capacity constrain the development of precisely those sectors that require complex production and transport chains.

The results of the analysis confirm that structural changes in Ukraine's exports are shaped by the influence of interconnected factors that often have

contradictory effects. EU institutional support and trade liberalisation compensate for some of the losses but simultaneously increase dependence on external rules and market conditions. Logistical innovations (the Danube corridor and alternative routes) expand export opportunities but cannot fully replace the pre-war maritime model. Production and structural changes promote the development of small and medium-sized enterprises but do not compensate for the loss of major industrial exporters in the short term.

Thus, the quantitative changes recorded in 2022–2024 should be viewed not as a completed model of a new export specialisation but as an intermediate outcome of adaptation to an exogenous wartime shock. The further evolution of the structure of Ukraine's exports will depend on the duration of the war, the restoration of maritime logistics, the pace of industrial reconstruction, and the ability of government policy to reconcile the requirements of European integration with the need to preserve the multi-vector nature of foreign trade. It is precisely in this context that the findings of the study open up scope for further academic debate and the development of strategic decisions, which are summarised in the article's conclusions.

Conclusions

A comprehensive analysis of the dynamics and structure of Ukraine's exports in 2010–2024 demonstrates that the country has undergone several successive stages of structural transformation: from a raw-material-oriented model dominated by CIS markets to a Europe-oriented system and, since 2022, to an adaptive export model shaped by the conditions of the full-scale war. The wartime shock has acted as a catalyst not only for a sharp decline in export volumes but also for profound changes in the geographical, commodity, and logistical configuration of exports.

The geographical reorientation of exports towards European Union markets represents the most extensive structural change throughout the entire period of Ukraine's independence: the EU's share increased from 24% in 2010 to over 60–66% in 2022–2024. This concentration was a forced response to the blockade of Black Sea ports and restrictions on maritime logistics, transforming the EU into a key geospatial "access hub" for Ukrainian exports to global markets. At the same time, the decline in exports to Asia and Africa demonstrated the critical dependence of Ukraine's multi-vector trade model on the uninterrupted functioning of maritime infrastructure.

Calculations of the Herfindahl–Hirschman Index confirm a sharp increase in the geographical concentration of exports in 2022–2023, reaching a high level (HHI ≈ 0.46–0.48), which indicates a narrowing of market diversification and the emergence of new systemic risks. Although a partial decline in concentration was recorded in 2024, its level remains substantially higher than pre-war values, limiting the resilience of the export system to future external shocks.

The identification of factors influencing Ukraine's merchandise exports during the war has shown that the current model of Ukrainian exports

is shaped by the simultaneous influence of institutional, logistical, production and structural, energy, financial, and security-related factors. On the one hand, EU institutional support, trade liberalisation, and the digitalisation of customs procedures have created conditions for rapid adaptation. On the other hand, the geospatial constraints imposed by the war, the destruction of industrial capacity, and the high cost of alternative logistics constrain the structural modernisation of exports and reinforce their agricultural and raw-material orientation.

Ukrainian exports are undergoing a profound structural transformation, the key characteristic of which is the acute contradiction between the strategic need for technological and sectoral modernisation and the forced adaptation to the severe geospatial and security constraints imposed by the war.

Prospects for further research include in-depth modelling of scenarios for the post-war transformation of Ukraine's export structure, assessing the impact of logistical diversification on reducing geographical concentration, and developing export policy instruments aimed at strengthening sectoral modernisation and expanding sales markets.

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INSTITUTIONAL CHALLENGES TO THE DEVELOPMENT OF LAND CAPITAL IN UKRAINE

The article explores the essence and current state of the agricultural land market in Ukraine as a strategic determinant in the transformation of the national agro-industrial complex under martial law. The study identifies key factors that have historically hindered the development of land relations: the prolonged moratorium, the shadow rental market, soil degradation, and the chronic undercapitalization of the sector. The research hypothesis posits that the current liberalized land market model, amid war and institutional weakness, leads to excessive land concentration and worsened soil degradation. This necessitates immediate adjustments to strengthen environmental controls and protect small producers, drawing on the practices of European countries. The methodological foundation of the study is a systems approach incorporating statistical analysis to evaluate land fund losses, comparative analysis to contrast Ukrainian and Polish market regulation models, and a structural-logical method to define state policy priorities. The research relies on data from the StateGeoCadastre, the Ministry of Economy of Ukraine, and analytics from international institutions. The study confirms that under the full-scale armed aggression of the Russian Federation, domestic land capital has suffered catastrophic losses. These are evident in the extensive mining of vast territories, heavy metal contamination of chernozems, and the destruction of southern irrigation systems following the breach of the Kakhovka HPP. An analysis of the land market's implementation (from 2021 to early 2026) shows that despite granting market

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ІНСТИТУЦІЙНІ ВИКЛИКИ РОЗВИТКУ ЗЕМЕЛЬНОГО КАПІТАЛУ В УКРАЇНІ

Розкрито сутність та поточний стан функціонування ринку земель сільськогосподарського призначення в Україні як стратегічного детермінанта трансформації національного агропромислового комплексу в умовах воєнного стану. Визначено ключові чинники, що історично гальмували розвиток земельних відносин: тривала дія мораторію, тінізація оренди, деградація ґрунтів та хронічна недокапіталізація галузі. Дослідження ґрунтується на гіпотезі, що діюча лібералізована модель ринку землі в умовах війни та інституційної слабкості призводить до надмірної концентрації земель та посилення деградації ґрунтів, що потребує негайного коригування в бік посилення екологічного контролю та захисту малих виробників за прикладом європейських країн. Методологічною основою статті є системний підхід, в межах якого застосовано статистичний аналіз для оцінки втрат земельного фонду, порівняльний аналіз для зіставлення української та польської моделей регулювання ринку, а також структурно-логічний метод для визначення пріоритетів державної політики. Дослідження спирається на дані Держгеокадастру, Міністерства економіки України та аналітику міжнародних інституцій. Підтверджено, що в умовах повномасштабної збройної агресії рф вітчизняний земельний капітал зазнав катастрофічних втрат, що проявляються у тотальному мінуванні значних територій, хімічному забрудненні чорноземів важкими металами та руйнуванні іригаційних систем півдня внаслідок підриву Каховської ГЕС. Проаналізовано результати впровадження ринку землі (з 2021 до

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access to legal entities, market dynamics remain moderate, land prices in foreign currency equivalent are the lowest in Europe, and there is no massive influx of investment due to high security risks. A comparative analysis of Poland's strictly regulated (social) land market model and Ukraine's liberalized model confirms the hypothesis regarding the urgent need to enhance state environmental oversight and protect small farming enterprises. The research highlights that excessive land concentration by the corporate sector poses a particular threat when inspection measures are relaxed. It is demonstrated that an effective post-war transformation requires a comprehensive approach encompassing systematic humanitarian demining, land reclamation, preferential lending for small agribusinesses using land as collateral, and the innovative reconstruction of irrigation systems. The article emphasizes the importance of harmonizing national land legislation with EU standards, which will help restore agricultural potential and solidify Ukraine's position as a key guarantor of global food security.

Keywords: land reform, agrarian transformation, food security, agricultural lands, land market, degradation.

початку 2026 рр.), які продемонстрували, що, попри допуск до ринку юридичних осіб, динаміка залишається поміркованою, ціна у валютному еквіваленті є найнижчою в Європі, а масового припливу інвестицій не спостерігається через високі безпекові ризики. На основі порівняльного аналізу встановлено наявність жорстко регульованої (соціальної) моделі ринку землі Польщі та лібералізованої моделі України, що підтверджує гіпотезу про нагальну потребу в посиленні державного екологічного контролю та захисті малих фермерських господарств. Виявлено, що особливу небезпеку становить надмірна концентрація земель корпоративним сектором за умов послаблення інспекційних заходів. Доведено, що ефективна повоєнна трансформація потребує комплексного підходу, який поєднує системне гуманітарне розмінування, рекультивацію земель, запровадження пільгового кредитування для малого агробізнесу під заставу землі та інноваційну відбудову систем зрошення. Наголошено на важливості гармонізації національного земельного законодавства з нормами ЄС, що дозволить відновити аграрний потенціал та зміцнити статус України як ключового гаранта світової продовольчої безпеки.

Ключові слова: земельна реформа, аграрна трансформація, продовольча безпека, сільськогосподарські землі, ринок землі, деградація.

JEL Classification: Q15, Q18, R52, P32.

Introduction

Land in Ukraine is not merely an economic asset or a means of production; it is a fundamental substrate of national identity, the fundamental wealth of the people, and the state's most powerful strategic resource on a global scale. Under conditions of an existential threat caused by the full-scale war, the agricultural sector has become a key stabilizer of the national economy, accounting for more than 10% of GDP and generating a critical share of foreign-currency export revenues. Within its internationally recognized borders, Ukraine possesses more than 42 million hectares of agricultural land, of which approximately 32 million hectares are arable land. In terms of the proportion of arable land (56.8% of its total area), the country ranks third in the world (Skilky-skilky, 2025, December 19).

The transformation of land relations, which effectively began with the restoration of independence, was artificially impeded by the accumulation of critical systemic distortions, namely, the total lack of control over land

conservation, compliance with crop rotation requirements, and the application of organic and mineral fertilizers; widespread ploughing; the decommissioning of existing irrigation systems; insufficient capitalization of the sector; a lack of investment in complex infrastructure (irrigation and perennial plantations); the shadowing of land lease relations; the transfer of land out of state ownership; and the consequences of the Russian Federation's illegal invasion.

Russia's military aggression has brought about catastrophic changes in Ukraine: at least 10 000 hectares of agricultural land are potentially contaminated with landmines and unexploded ordnance, while approximately 1 million hectares of agricultural land remain suspected of contamination. The destruction of the Kakhovka Hydroelectric Power Plant not only damaged fertile soil layers but also effectively eliminated the irrigation system in the south of the country, leaving approximately 600 000 hectares of agricultural land without irrigation (*Foreign Ukraines*, 2026). To date, Ukraine continues to face both the substantial problems accumulated over years of neglect and those arising from the war. At present, direct and indirect losses in the agricultural sector amount to nearly UAH 6.4 trillion (Ministry of Economy and Environment of Ukraine, 2026, March 17).

To bring land out of the shadow economy, attract investment, and ensure the professional management of land capital, Ukraine adopted Law of Ukraine No. 552-IX "On Amendments to Certain Legislative Acts of Ukraine Regarding the Conditions of Agricultural Land Circulation" (2020, March 31), which provided for the phased opening of the land market beginning on July 1, 2021, followed by its full-scale phase starting on January 1, 2024 (i.e., allowing legal entities to acquire land, subject to an ownership limit of 10 000 hectares). These changes were expected to constitute an important milestone in establishing a transparent investment environment.

At the same time, this legislation was preceded by a series of events that significantly influenced the formation of the land market in Ukraine:

- 1991–2001: *the stage of denationalization and land-share allocation*, which resulted in the creation of more than 7 million private landowners. However, they were not granted the right to dispose of (sell) this asset (Law of Ukraine No. 899-IV "On the Procedure for Allocating Land Plots to Owners of Land Shares (Units) in Kind (on the Ground)," 2003, June 5);
- 2001–2021: *the era of the moratorium*. However, the moratorium was lifted following the European Court of Human Rights' 2018 judgment in Zelenchuk and Tsytsyura v. Ukraine, in which the Court found that an absolute ban on land sales violated Article 1 of Protocol No. 1 to the Convention for the Protection of Human Rights and Fundamental Freedoms (the right to peaceful enjoyment of possessions) (European Court of Human Rights, International Courts, Case of Zelenchuk and Tsytsyura v. Ukraine (Applications Nos. 846/16 and 1075/16), 2018, May 22);

• 2021–2023: *the opening of the land market to individuals* (up to 100 hectares) (Government Portal, 2022, July 1);

• since 2024: *access to the market for legal entities* (a limit of 10 000 hectares), which is intended to attract large-scale investment capital, promote effective land management, and ensure land preservation (AgroPolit, 2024, January 1).

The academic debate surrounding land transformation in Ukraine has a long history. Leading scholars Kaletnik and Tomlyak (2022), in their works, focus on the challenges posed by martial law, emphasizing the need to analyze the proportion of state-owned and municipally owned land, reconsider its designated purpose, and simplify the mechanism for acquiring rights to use agricultural land plots. These measures would facilitate the cultivation of such land under martial law in Ukraine with the aim of ensuring the country's food security. Hadzalo (2022) investigated the implementation of scientifically grounded approaches to ensuring food stability that take contemporary challenges into account and are aimed at the sustainable development of rural areas.

The economic principles of land market liberalization and strategies for market development through 2024 are presented in the work of Nizalov (2024). In his publications, scholar Luzan (2008) emphasizes that the ultimate goal of privatization is to transform land into "functioning capital", which would enable peasants and farmers to obtain credit on equal terms with their European counterparts. Representatives of businesses and local communities have repeatedly raised the issue of protecting small farms and preventing excessive land concentration (Holos Ukrainy, 2019, October 4). However, an analysis of the land market during wartime and an assessment of its development prospects in the post-war period require further research.

The purpose of this article is to substantiate the need to transition to a socially oriented ecological model for regulating the agricultural land market in Ukraine and to identify the strategic priorities of state land policy during the post-war recovery phase in order to overcome the consequences of armed aggression. The research objectives include assessing losses of land resources, analyzing price and structural trends in the land market, and developing recommendations for public authorities.

The study is based on the hypothesis that the current liberalized land market model in Ukraine, under conditions of martial law and institutional weakness of state supervisory authorities, leads to excessive land concentration in the corporate sector and increased soil degradation. Therefore, effective post-war recovery will require temporary adjustments to land policy toward a socially oriented model, with strengthened environmental oversight and support for small farms.

The methodological framework of the article is based on a systems approach to the study of land relations. The study employs statistical analysis (to assess changes in the land fund and land market indicators); comparative

analysis (to compare the land market models of Ukraine and Poland); the structural and logical method (to identify the consequences of military aggression for various segments of the agricultural sector); and the generalization method (to formulate conclusions and state policy priorities). The information base comprises regulatory legal acts, data from the StateGeoCadastre, the Ministry of Economy of Ukraine, reports by international organizations, and academic publications.

The main body of the article is structurally divided into two logically interconnected sections. The first assesses the scale of losses and degradation of Ukraine's land fund resulting from military hostilities. The second analyzes trends in land transactions, the impact of opening the market to legal entities, and provides a comparative assessment of Poland's experience in land market regulation.

1. Assessment of Ukraine's land capital losses resulting from military aggression

Amid global challenges, food security is becoming a subject of intense geopolitical confrontation. According to the United Nations, against the backdrop of climate anomalies and armed conflicts, the number of people experiencing acute hunger has risen to a record 295 million (Finteco, 2023, May 17). With its vast resources of arable land, Ukraine is not merely a producer but also a guarantor of stability for many countries of the Global South (*Table 1*).

Table 1

Global ranking of countries by the share of arable land in total land area

Ranking	Country	Country area, thousand ha	Arable land area, thousand ha	% of arable land	Global significance
1	Bangladesh	14 846	8 200	60.6	Supplying the domestic market of South Asia
2	Denmark	4 309	2 365	59.1	Leader in intensive livestock farming and seed production
3	Ukraine	60 355	32 924	56.8	Global exporter of cereals, oilseeds, and sunflower oil
4	Moldova	3 385	1 871	56.8	Export of fruit and vegetable products and grapes
5	India	328 726	153 858	51.8	Leading producer of rice, wheat, and sugar

Source: compiled by the author based on (Skilky-skilky, 2025, December 19).

To assess trends in the development of land relations, it is advisable to analyze the dynamics of land use in Ukraine (*Figure* 1).

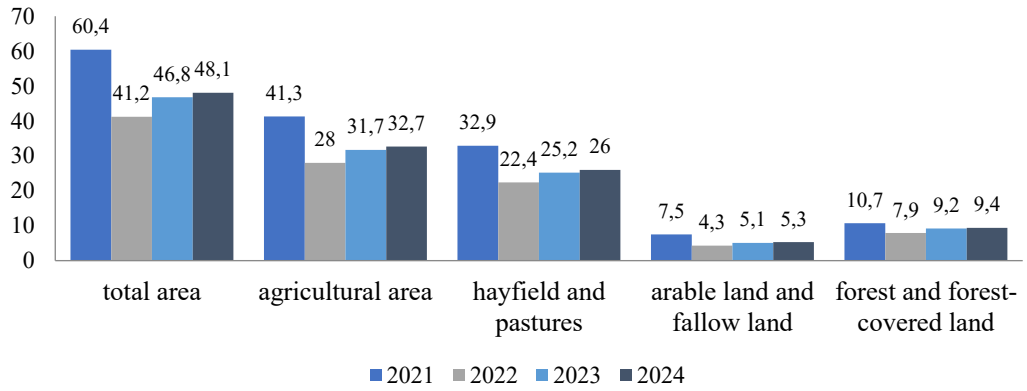


Figure 1. Dynamics of Ukraine's land resources in 2021–2024, thousand hectares

Source: compiled by the author based on (*Nykoliuk et al*., 2024).

The data in *Figure 1* demonstrate the devastating impact of the full-scale invasion on the amount of available land resources. In 2022, an unprecedented decline occurred across all categories of land under control and available for economic use, with figures falling by nearly one-third compared with the pre-war period. A substantial decrease was observed both in the total area of agricultural land and in the areas of arable land and fallow land specifically. As a result of the occupation and hostilities during the first year of the full-scale war, the country lost the ability to cultivate a significant area of arable land. During 2023–2024, the de-occupation of some territories and active demining efforts contributed to a positive trend toward the partial recovery of agricultural land areas. However, the 2024 figures remained significantly below the pre-war level of 2021, confirming the enormous damage and long-term losses to the country's agricultural potential.

Such a high proportion of ploughed land in Ukraine is not only an advantage but also a challenge. Ukraine must transition to a regenerative agriculture strategy to preserve its unique humus layer from erosion, particularly given the substantial land degradation caused by military hostilities. The Russian Federation's military aggression has resulted in the physical and chemical destruction of Ukrainian land (*Table 2*).

Table 2

Analysis of losses and degradation of Ukraine's land capital resulting from russia's full-scale invasion

Type of pollution	Estimated costs, trillion UAH	Nature of the problem	Solutions
Extensive landmining	1.34	At least 10,000 hectares of agricultural land are potentially contaminated with landmines, creating "dead zones" that cannot be cultivated	Humanitarian demining
Chemical contamination	1.15	Heavy metal and explosive contamination: each shell explosion releases heavy metals (lead, cadmium, and manganese) and rocket fuel residues into the soil	Land reclamation using specialized bacteriological and chemical remediation methods

End of Table 2

Type of pollution	Estimated costs, trillion UAH	Nature of the problem	Solutions
Destruction of irrigation systems (southern regions)	0.12	Collapse of irrigation following the destruction of the Kakhovka Hydroelectric Power Plant	Development of new micro-irrigation systems and a transition to drought-resistant crops
Kakhovka disaster		Siltation and destruction of the upper soil layers	Phytomelioration, afforestation of degraded areas, and updating soil maps
Threats to biodiversity	3.8	Many animal and plant species are on the verge of extinction	Establishment of new protected areas and monitoring
Disruption of the Chornobyl Exclusion Zone ecosystem		Disturbance of the upper soil layers within the Chornobyl Radiation and Ecological Biosphere Reserve, which exposed radioactive soil layers and disrupted biodiversity	Radiological monitoring, land reclamation, and access restrictions

Source: compiled by the authors based on (Ministry of Economy and Environment of Ukraine, 2026, March 17).

Addressing all the problems listed above is impossible without substantial investment and sound agricultural policy. The introduction of the land market was intended to create opportunities to attract investment and transfer land to new owners who would take care of and preserve their property.

2. Analysis of land market functioning and european experience in regulation

At this stage, the results of the land reform have been analyzed (*Table 3*).

Table 3

Dynamics of the agricultural land market in Ukraine (2021 – early 2026)

Year	Area of Land Sold (thousand hectares)	Buyers (volume/share of transactions)	Average Price per Hectare, UAH / Breakdown
2021 (from 1 July)	100.3	Predominantly individuals	32 972
2022	69.2		34 202
2023	114.1		38 804
2024	320.6	Individuals (242 thousand hectares) Legal entities (78 thousand hectares)	46 678 / Legal entities: 62 656 Individuals: 41 510
2025	356.5	Individuals (62.5%) Legal entities (37.5%)	57 408 / Legal entities: 74 404 Individuals: 47 202
Early 2026 (until March)	40.3		64 631 / Legal entities: 84 643 Individuals: 52 268
Entire period	over 1 000,0 (1 млн га)	Agricultural producers – specialised buyers; non-specialised investors	Prices have increased by 96% since the market launch

Source: compiled by the author based on (Bashlyk, 2023).

According to *Table 3*, despite the opening of the market to legal entities in 2024 (agricultural companies and corporate businesses), there was no sharp increase in prices. The average price showed an upward trend, with prices in the legal-entity segment being significantly higher than those in other categories of buyers. However, in foreign currency terms, this figure remains extremely low compared with EU countries. Since 2021, more than 1 million hectares have been sold, accounting for approximately 3% of the available agricultural land. The market remains moderate, with no signs of a mass sell-off of assets.

A comparative analysis was conducted of the implementation of land reform in Ukraine and the existing system in neighbouring Poland (*Table 4*).

Table 4

Comparative Analysis of the Agricultural Land Markets in Ukraine and Poland

Criterion	Ukraine	Poland
Agricultural land area, million hectares	Agricultural land area, million hectares	Agricultural land area, million hectares
Average price, USD/ha	Average price, USD/ha	Average price, USD/ha
Who is eligible to purchase land	Ukrainian individuals and, since January 2024, legal entities	Individuals with agricultural education or farming experience; EU citizens (restrictions lifted in 2016)
Maximum area per buyer, ha	Up to 10 000 (since January 2024)	Up to 500
Market model	Liberalised, with phased opening and restrictions	Strictly regulated (conservative/social), aimed at preserving and developing family farms
State control	Moderate. Land concentration is controlled within established limits. Buyers' sources of funds must be verified by notaries and the StateGeoCadastre.	Very strict. The state regulates the market through specialised bodies (the Agricultural Property Agency / KOWR), which have the right of first refusal. A tax on the sale of agricultural land (2–5% of the value) applies.

Source: compiled by the author based on (AgroPolit, 2017, June 17; 2017, March 16; Komentari, 2025, July 7).

The Polish model provides substantial protection for small family farms and envisages stricter state oversight (land may be confiscated in cases of misuse or failure to cultivate it). In Ukraine, the StateGeoCadastre and the State Environmental Inspectorate are responsible for monitoring land use and protection. However, under martial law, inspection activities are severely restricted, creating risks of soil depletion.

The processes of transforming land relations have been intensified by digitalization. The introduction of electronic auctions for leasing and selling state- and municipally owned land is intended to serve as the main safeguard against corruption. The normative monetary valuation serves as a price "floor" below which land sales are prohibited, protecting land-share owners

from speculative pressure under wartime conditions. In addition, the Prozorro.Sale system makes it possible to monitor land concentration, preventing monopolization exceeding 10,000 hectares.

The state program "5–7–9" has become the main source of financing for farmers purchasing land. Furthermore, since January 1, 2024, the banking system has begun accepting land as highly liquid collateral.

Modern judicial practice is currently developing with regard to the resolution of disputes involving the termination of lease agreements due to the impossibility of using land plots for agricultural production as a result of hostilities, as well as compensation for war-related losses (Resolution of the Supreme Court of Ukraine No. 7 "On the Practice of Applying Land Legislation by Courts in the Consideration of Civil Cases," 2004, April 16). The issue of free privatization remains critical (Land Code of Ukraine No. 2768-III, 2001, October 25, Articles 116 and 121 of the Land Code of Ukraine), as under free-market conditions it creates unequal opportunities and becomes a source of corrupt practices. The issues of allocating land plots to combatants and finding possible solutions for internally displaced persons (IDPs) also require further consideration. Scholars propose replacing this provision with targeted financial assistance to enable certain categories of citizens to purchase land.

The land market stimulates decentralization. According to the results of land auctions conducted through the Prozorro.Sale system between 2021 and May 2026, the total value of transactions reached UAH 10 billion (Ministry of Economy and Environment of Ukraine, 2026, May 7). Rising lease and sale prices increase local community budget revenues, enabling them to finance the restoration of schools, hospitals, and bomb shelters. This helps create conditions for the return of rural residents and agricultural professionals in the post-war period. The future transformation of the agricultural sector depends on how quickly the war ends, the occupied territories are de-occupied, recovery is carried out, and integration into the EU common markets is achieved.

Conclusions

The conducted study provides grounds for drawing objective, pragmatic conclusions regarding the state of land reform:

- the launch of the land market did not lead to a rapid economic leap for the country. Over five years, approximately 1 million hectares entered the market (about 3%);
- the introduction of the possibility of holding dual citizenship may affect the land market, which raises concerns;
- the average price in foreign currency terms (approximately USD 1.000/ha) remains the lowest in Europe, reflecting high security risks, export logistics problems, and declining profitability in agribusiness;
- the admission of legal entities to the market in 2024, given the continued hostilities in Ukraine, demonstrated that businesses are not ready to invest on a large scale in land purchases, preferring long-term leases.

The research hypothesis has been fully confirmed. Weak state oversight of soil conditions remains an urgent problem. Given the 10 000-hectare ownership limit, Ukraine is moving toward the development of large corporate farms, which requires the introduction of strict environmental standards and support programs for small farmers; otherwise, they will be unable to withstand competition.

The scientific novelty of the study lies in the comprehensive integration of an assessment of the environmental and war-related losses to Ukraine's land capital with an analysis of the results of the second stage of land reform (the admission of the corporate sector), which made it possible to substantiate the need to transition from a purely liberal model to a socially oriented ecological model of land market regulation.

The practical value of the results obtained lies in identifying clear guidelines for public authorities. The key priorities of state land policy for the coming years should include:

- comprehensive demining of de-occupied territories;
- a program to restore the chemical and physical condition of soils following hostilities;
- the development of lending mechanisms for small farmers secured by land at affordable interest rates;
- the search for alternative water sources and the reconstruction of irrigation systems based on new technological principles in the southern regions;
- strengthening the institutional capacity of the StateGeoCadastre in environmental monitoring.

Prospects for further research in this area lie in the gradual harmonization of land legislation with EU standards as part of the European integration process.

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THE CONTRIBUTION OF CREATIVE INDUSTRIES INTO ECONOMIC DEVELOPMENT OF UKRAINE

The relevance of the study is determined by the growing role of creative industries in generating employment, entrepreneurial activity, exports, and forms of value creation, as well as by the lack of an approach to assessing their contribution to Ukraine's economic development. The study is based on the hypothesis that this contribution is multidimensional and cannot be objectively measured using a single indicator. To test the hypothesis, a system of economic, entrepreneurial, labour, export, innovation and digital, and regional indicators was developed. The composite assessment included comparable statistical series for 2020–2024, normalised using the min–max method and combined into sub-indices of entrepreneurial activity, economic contribution, labour contribution, and export capacity. The results revealed unstable and structurally heterogeneous dynamics of the sector. The highest value of the composite index was recorded in 2021 (0.879); it declined to 0.423 in 2023 and increased to 0.688 in 2024. It was established that the substantial entrepreneurial presence of creative industries does not ensure a proportional economic return: in 2024, the sector

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ВНЕСОК КРЕАТИВНИХ ІНДУСТРІЙ В ЕКОНОМІЧНИЙ РОЗВИТОК УКРАЇНИ

Актуальність дослідження зумовлена зростанням ролі креативних індустрій у формуванні зайнятості, підприємницької активності, експорту та форм створення вартості, а також відсутністю підходу до оцінювання їх внеску в економічний розвиток України. В основу дослідження покладено гіпотезу, що такий внесок має багатовимірний характер і не може бути об'єктивно визначений за одним показником. Для її перевірки сформовано систему економічних, підприємницьких, трудових, експортних, інноваційно-цифрових та регіональних показників. До інтегрального оцінювання включено зіставні статистичні ряди за 2020–2024 рр., нормовані методом мінімум-максимум і об'єднані у часткові індекси підприємницької активності, економічного внеску, трудового внеску та експортної спроможності. Результати засвідчили нестабільну й структурно неоднорідну динаміку сектору. Найвище значення інтегрального індексу отримано у 2021 р. (0.879), у 2023 р. він знизився до 0.423, у 2024 р. зріс до 0.688. Встановлено, що підприємницька представленість не забезпечує пропорційної економічної віддачі: у 2024 р. на сектор припадало 14.72%

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accounted for 14.72% of active business entities but only 1.79% of total sales. Structural polarisation within the sector and the dominance of IT, information services, advertising, and communications were identified. The research hypothesis was confirmed. The proposed approach makes it possible to assess both the overall dynamics and the internal structure of the contribution of creative industries and may be used to monitor the effectiveness of national and regional policies supporting the sector.

Keywords: creative industries, economic development, economic contribution assessment, composite index, structural analysis.

діючих суб'єктів господарювання, але лише 1.79% загального обсягу реалізації. Виявлено структурну поляризацію сектору та домінування IT, інформаційних послуг, реклами і комунікацій. Наукову гіпотезу підтверджено. Запропонований підхід дає змогу оцінювати загальну динаміку і внутрішню структуру внеску креативних індустрій та може використовуватися для моніторингу результативності державної і регіональної політики підтримки сектору.

Ключові слова: креативні індустрії, економічний розвиток, оцінювання економічного внеску, інтегральний індекс, структурний аналіз.

JEL Classification: C43, L26, O10, Z10.

Introduction

Creative industries are playing an increasingly important role in the modern economy by transforming knowledge, creative abilities, digital technologies, and intellectual property into economic outcomes. According to United Nations Trade and Development (UNCTAD), global exports of creative services amounted to USD 1.7 trillion in 2024, while their share of global services exports reached 20% (UNCTAD, 2026).

At the same time, assessing the contribution of creative industries remains a complex methodological task. According to UNCTAD estimates, the creative economy accounts for between 0.5% and 7.3% of gross domestic product across countries and for between 0.5% and 12.5% of employment (UNCTAD, 2024a). These differences are associated with differing approaches to defining sector boundaries and accounting for self-employment, digital services, and intangible assets. Another important problem is the fragmented nature of existing assessments, in which the number of business entities, employment, sales volumes, and exports are analysed separately and therefore do not provide a comprehensive view of the sector's performance.

For Ukraine, this issue is of particular importance in the context of the full-scale war. The digital nature of creative activity, remote work, and orientation towards external markets contribute to maintaining entrepreneurial activity. However, the quantitative presence of business entities is not always accompanied by corresponding sales volumes, employment, and labour productivity. Therefore, the contribution of creative industries should be assessed by taking into account the interrelationship among its entrepreneurial, economic, labour, and export components.

International approaches to measuring the creative economy have been developed by United Nations Trade and Development (UNCTAD), the UNESCO Institute for Statistics (UIS), and the World Intellectual Property Organization (WIPO). These approaches cover different aspects of the sector's functioning but do not provide a universal composite indicator of its economic contribution (UNCTAD, 2024b; UIS, 2025; WIPO, 2026).

The potential for using composite indicators was examined by Daubaraitė-Radikienė and Startienė (2022). Further development of this line of research is reflected in recent international studies. Mikulić and Jelušić (2026), having reviewed approaches to constructing composite indices for the creative economy, identify a number of methodological limitations associated with the selection of components of such indices, robustness and sensitivity testing of the results, their validity, and the possibility of decomposition. Rania et al. (2026) assessed urban creativity by combining cultural heritage and creative economy indicators using DEA, SFA, and entropy weighting. Their findings demonstrated that individual components contribute unequally to the overall assessment.

Recent studies also confirm that the economic performance of creative industries depends on the regional, institutional, and technological conditions under which they operate. Homsombat et al. (2025), examining regions of Thailand, found a positive effect of the creative economy and a favourable environment on regional economic outcomes, whereas cultural activity alone did not produce a comparable effect. Of particular relevance to Ukraine are the findings of Arauzo-Carod and Moroz (2025), who used data for 2013–2020 to examine the effect of territorial proximity to regions affected by military conflict on the development of cultural and creative industries and emphasised their role in future economic recovery. Valiati and Möller (2025), analysing the development of cultural and creative industries in the context of the Fourth Industrial Revolution, highlight digital dependence, structural heterogeneity, and differences in the capacities of individual segments of the sector.

Certain aspects of the development of creative industries in Ukraine have been examined by Zabaldina et al. (2025), Samiilenko (2020), and Kaleniuk and Kuznetsova (2022). The present article, in turn, continues the authors' previous research (Niedielko, 2024; Osadcha & Niedielko, 2025a, 2025b). At the same time, a comprehensive assessment of the contribution of creative industries to Ukraine's economic development that would combine entrepreneurial, economic, labour, and export components and enable the identification of internal imbalances in the formation of this contribution remains insufficiently developed.

The purpose of this article is to substantiate and test a methodological approach to the composite assessment of the contribution of creative industries to Ukraine's economic development. To achieve this purpose, a system of indicators was developed, sub-indices and a composite index were constructed, and the results for 2020–2024 were assessed.

The study is based on the hypothesis that the contribution of creative industries is multidimensional and cannot be objectively determined using a single indicator. The hypothesis was tested using official data from the State Statistics Service of Ukraine. The composition of the sector was defined in accordance with Order No. 265-r of the Cabinet of Ministers of Ukraine dated

24 April 2019 and the Classification of Economic Activities DK 009:2010 (Cabinet of Ministers of Ukraine, 2019; State Committee of Ukraine for Technical Regulation and Consumer Policy, 2010). Indicators for 2020–2024 were normalised using the min–max method and aggregated into indices of entrepreneurial activity, economic contribution, labour contribution, and export capacity. The composite index was calculated as the arithmetic mean of the sub-indices.

The limitations of the study are associated with incomplete official statistics. Gross value added was excluded from the composite assessment because comparable data for 2024 were unavailable, regional indicators because of their static nature, and the share of micro-entities because of the ambiguity of its economic interpretation. Official statistics also do not fully capture freelancing and platform employment. Therefore, the proposed index should be regarded as a tool for the comparative assessment of the dynamics of the creative sector.

The main body of the article is structured into three sections. The first section summarises approaches to assessing creative industries and develops a system of indicators of their contribution to economic development. The second section substantiates the procedure for normalising the indicators and constructing the sub-indices and the composite index. The third section applies the proposed approach to Ukrainian data for 2020–2024 and analyses the dynamics and structure of the contribution of creative industries to economic development.

1. Methodological foundations for Assessing the contribution of creative industries to economic development

In international practice, the assessment of creative industries is based on different approaches. The *UNESCO Institute for Statistics* (*UIS*) considers them a component of the cultural and creative ecosystem; *United Nations Trade and Development* (*UNCTAD*) focuses on economic contribution and international trade; the *World Intellectual Property Organization* (*WIPO*) focuses on the creation and commercialisation of copyright-protected works; and the UK *Department for Culture, Media and Sport* (*DCMS*) focuses on value added, employment, the number of enterprises, and exports (*UNESCO Institute for Statistics*, 2025; *UNCTAD*, 2024; *WIPO*, 2015; *DCMS*, 2016). The application of these approaches in Ukraine requires adaptation to the national classification of economic activities and the available statistical base.

In Ukraine, the composition of creative industries is defined by Order No. 265-r of the Cabinet of Ministers of Ukraine dated 24 April 2019, while they are statistically identified using the relevant KVED-2010 codes (Cabinet of Ministers of Ukraine, 2019; State Committee of Ukraine for Technical Regulation and Consumer Policy, 2010). This approach makes it possible to delineate the boundaries of the sector under study and ensure the comparability of indicators; however, it does not fully account for creative activity within other types of economic activity, self-employment,

freelancing, and platform work. The transition to the *NACE* 2.1-UA classification from 1 January 2027 will require revising the composition of creative industries and ensuring the comparability of statistical data compiled under the current and new classifications.

In our view, the indicators used to assess the contribution of creative industries should be grouped into six blocks: economic, entrepreneurial, labour, export, innovation and digital, and regional. The authors have systematised the set of indicators that may be used for such an assessment (*Table 1*).

Table 1

System of Indicators for Assessing the Contribution of Creative Industries to Economic Development

Block	Key indicators	Assessment focus
Economic	Value added; sales volume; sector share in the economy; labour productivity	Scale and performance of the sector
Entrepreneurial	Number of active business entities; enterprises and individual entrepreneurs; share of micro-entities	Entrepreneurial activity and business structure
Labour	Number of employed persons; number of employees; share of employed persons	Contribution to employment and the use of human capital
Export	Exports of creative goods and services; share and dynamics of exports	Export capacity of the sector
Innovation and digital	Indicators of digital activities; intellectual property assets	Digitalisation and commercialisation of intangible assets
Regional	Regional share in the number of business entities; density of creative businesses; localisation	Spatial concentration of the sector

Note. The composite assessment for 2020–2024 includes the economic, entrepreneurial, labour, and export blocks. Innovation and digital indicators, as well as regional indicators, are analysed separately because complete comparable time series are unavailable.

Source: compiled by the authors based on UIS (2025), UNCTAD (2024a, 2024b), WIPO (2015), DCMS (2016), the Cabinet of Ministers of Ukraine (2019), and KVED-2010.

It should be noted that these blocks should be analysed in relation to one another, since quantitative growth of the sector is not always accompanied by a corresponding improvement in its economic performance. At the same time, certain indicators require careful interpretation. In particular, a high share of micro-entities may indicate both the development of entrepreneurial initiative and the fragmentation of the sector, while official statistics do not fully capture self-employment, freelancing, and platform employment.

2. Construction of sub-indices and the composite index of the contribution of creative industries

Given the availability of complete and comparable data for 2020–2024, the composite assessment was conducted across four dimensions: entrepreneurial activity, economic contribution, labour contribution, and export capacity. Innovation and digital indicators and regional indicators

were not included because complete time series were unavailable, while regional data were used separately to characterise the spatial structure of the sector in 2024. Gross value added was not included because a comparable value for 2024 was unavailable, and the share of micro-entities was not included because of the ambiguity of its economic interpretation.

The indicators selected for calculating the sub-indices are expressed in different units of measurement. To ensure their comparability, the min–max method was applied. This method is one of the commonly used approaches to data normalisation in the construction of composite indicators (Organisation for Economic Co-operation and Development, & European Union, 2008). Its application allows the observed values to be rescaled to the interval from 0 to 1.

The indicators were normalised using the following formula:

$$Z_{ij} = \frac{X_{ij} - X_{imin}}{X_{imax} - X_{imin}}, \quad (1)$$

where: Z_{ij} is the normalised value of the (i)-th indicator in year (j);

X_{ij} is the observed value of the (i)-th indicator in year (j);

X_{imin} and X_{imax} are, respectively, the minimum and maximum values of the (i)-th indicator over the period 2020–2024.

All indicators included in the calculation are stimulants. An increase in their values indicates an increase in the contribution of creative industries in terms of entrepreneurial activity, economic performance, employment, or exports. For destimulant indicators, the methodology provides for an inverse normalisation procedure; however, such indicators were not used in the initial application of the methodology.

At the same time, normalised values of 0 and 1 should not be interpreted as critical and optimal levels of sector development. They represent the minimum and maximum values, respectively, of the relevant indicator only within the period under study.

The entrepreneurial activity index was calculated as the arithmetic mean of the normalised number of active business entities in the creative industries and their share in the total number of active business entities:

$$\mathrm{I}_{EA,j} = \frac{Z_{1j} + Z_{2j}}{2}, \quad (2)$$

where: Z_{1j} is the normalised number of active business entities in the creative industries in year (j);

Z_{2j} is the normalised share of creative industries in the total number of active business entities.

The use of both absolute and relative indicators makes it possible to assess not only changes in the number of business entities but also the position of creative industries within the structure of the business sector.

The economic contribution index includes the normalised values of sales volume, the share of creative industries in total sales, and labour productivity:

$$I_{EC,j} = \frac{Z_{3j}+Z_{4j}+Z_{5j}}{3}, \quad (3)$$

where: Z_{3j} is the normalised sales volume of products, goods, and services;
Z_{4j} is the normalised share of creative industries in total sales;
Z_{5j} is the normalised labour productivity.

Labour productivity was calculated as the ratio of the sales volume of products, goods, and services to the number of employed persons in the creative industries. Thus, the index reflects not only the scale of the sector's activities but also the efficiency of labour utilisation.

The labour contribution index was constructed using the number of employed persons and employees:

$$I_{LC,j} = \frac{Z_{6j}+Z_{7j}}{2}, \quad (4)$$

where: Z_{6j} is the normalised number of employed persons in the creative industries;
Z_{7j} is the normalised number of employees.

Distinguishing between these indicators is particularly important for the creative sector. The number of employed persons reflects overall labour participation, whereas the number of employees reflects the sector's capacity to create formal jobs.

The export capacity index was determined based on the normalised volume of exports of creative-digital services:

$$I_{EXC,j} = Z_{8j}, \quad (5)$$

where: Z_{8j} is the normalised volume of exports of creative-digital services in year (j).

Including the export component makes it possible to account for the role of creative industries in generating foreign earnings. This is particularly important for digital and information services, which can be provided remotely in international markets.

To calculate the composite index, equal weights were assigned to the sub-indices. In our view, at the stage of testing the methodology, this approach is the most justified, since there are insufficient grounds for giving preference to any one of the components.

The composite index of the contribution of creative industries was calculated using the following formula:

$$I_j = \frac{I_{EA,j}+I_{EC,j}+I_{LC,j}+I_{EXC},j}{4}. \quad (6)$$

The composite index ranges from 0 to 1. An increase in its value indicates a strengthening of the overall contribution of creative industries across the dimensions examined, whereas a decrease indicates a deterioration in the results of one or more components.

At the same time, the composite index does not replace an analysis of its structure. The same value of the index may result from different combinations of the sub-indices. In particular, an increase in entrepreneurial activity is not always accompanied by a corresponding increase in sales volumes, employment, or labour productivity.

3. Assessment of the contribution of creative industries to Ukraine's economic development in 2020–2024

The proposed methodological approach was tested using data on Ukraine's creative industries for 2020–2024. The results of calculating the sub-indices and the composite index are presented in *Table 2*.

Table 2

Results of the Calculation of the Composite Index of the Contribution of Creative Industries to Ukraine's Economic Development

Year	Entrepreneurial activity index	Economic contribution index	Labour contribution index	Export capacity index	Composite index
2020	0.000	0.794	0.891	0.000	*0.421*
2021	0.606	0.999	1.000	0.910	*0.879*
2022	0.906	0.247	0.776	1.000	*0.732*
2023	0.904	0.055	0.000	0.733	*0.423*
2024	0.751	0.475	0.827	0.698	*0.688*

Note. The indices were calculated using the min–max method for stimulant indicators. The composite index includes indicators for which comparable time series for 2020–2024 were available. Value added, the share of micro-entities, and regional concentration were excluded because of comparability limitations or ambiguity in their economic interpretation.

Source: calculated by the authors based on official data from the State Statistics Service of Ukraine (n. d.-*a*, n. d.-*b*).

The highest value of the composite index was recorded in 2021 (see *Table 2*). During this period, the economic and labour contribution indices reached their highest values, while the export component also attained a high value. Thus, the 2021 result was driven by increases in sales volumes, labour productivity, employment, and exports.

In 2022, the composite index declined. At the same time, the entrepreneurial activity index increased, while the export capacity index reached its maximum value over the period under study. However, the economic contribution decreased substantially. This indicates that, during the first year of the full-scale war, creative industries maintained a substantial number of active business entities and a high level of export activity, but this did not offset the decline in sales volumes and labour productivity.

In 2023, the composite index was almost equal to its 2020 value (see *Table 2*). However, these similar values were formed by different combinations of the sub-indices. In 2020, the economic and labour components were higher, whereas in 2023 the entrepreneurial and export components were higher. At the same time, the economic and labour contribution indices reached their minimum values in 2023. This result indicates a substantial gap between the number of active business entities and the results of their activities. The labour contribution index for 2023 should be interpreted with due regard to gaps in employment statistics associated with the confidentiality of statistical information.

In 2024, the composite index increased. This increase was driven by the recovery of the economic and labour components, whereas the entrepreneurial activity and export capacity indices declined slightly. Therefore, the 2024 results indicate a partial recovery of the sector following the deterioration observed in 2023, but not a return to the 2021 levels.

In 2024, creative industries accounted for 14.72% of all active business entities but only 1.79% of total sales. Compared with 2021, sales volume decreased by 36.96% and labour productivity by 32.67% (calculated by the authors based on data from the State Statistics Service of Ukraine, n. d.-*b*). Thus, the substantial share of business entities in the creative industries within the business sector does not translate into a corresponding share of economic outcomes.

In 2024, micro-entities accounted for 99.3% of all business entities in the creative industries (calculated by the authors based on data from the State Statistics Service of Ukraine, n. d.-*b*). On the one hand, this indicates the accessibility of creative activity to self-employed persons and small-scale entrepreneurial initiatives. On the other hand, this structure points to the fragmentation of the sector and limited opportunities for scaling up activities.

The number of employed persons in the creative industries in 2024 was 383,016, including 128,954 employees (State Statistics Service of Ukraine, n. d.-*b*). The recovery of the labour contribution index compared with 2023 does not imply a return to the 2021 level. The low share of employees confirms the significant role of self-employment, which contributes to the flexibility of the sector but limits its contribution to the creation of stable jobs.

Exports of creative-digital services increased from USD 3068.3 million in 2020 to USD 4106 million in 2022, after which they declined to USD 3792.9 million in 2024 (calculated by the authors based on data from the State Statistics Service of Ukraine, n.d.-*a*). Despite this decline, the export volume remained higher than in 2020. At the same time, export activity did not offset the decrease in domestic sales volumes and labour productivity.

The results of the structural analysis showed that, in 2024, *IT* and information services accounted for 71.9% of business entities and 66.3% of sales volume. Together with advertising and communications, these activities

generated 83.5% of total sector sales (calculated by the authors based on data from the State Statistics Service of Ukraine, n.d.-*b*). At the same time, cultural, artistic, and certain professional activities recorded substantially lower levels of sales and labour productivity. Overall, this confirms the considerable internal heterogeneity of creative industries and the dependence of the sector's overall results on a limited range of digital and commercially oriented activities.

Thus, changes in the entrepreneurial, economic, labour, and export components during 2020–2024 were not synchronous. A comparison of the 2020 and 2023 results confirmed that similar values of the composite index may be formed by fundamentally different internal structures. Therefore, the composite index should be used together with the sub-indices, which makes it possible to identify the sources of its changes and reveal internal imbalances within the sector.

Conclusions

The study made it possible to substantiate and test a methodological approach to assessing the contribution of creative industries to Ukraine's economic development. For this purpose, a system of indicators was developed, sub-indices of entrepreneurial activity, economic contribution, labour contribution, and export capacity were constructed, and a composite index for 2020–2024 was calculated. The results obtained confirm that the research objective was achieved.

The calculations showed that the contribution of creative industries changed unevenly over the period under study. The highest value of the composite index was recorded in 2021. In 2023, it declined, but increased markedly in 2024. The recovery observed in 2024 was driven primarily by the economic and labour components; however, it did not represent a return to the 2021 results. At the same time, in 2024, creative industries accounted for 14.72% of all active business entities, while their share of total sales was only 1.79%. Thus, maintaining a substantial number of business entities does not in itself indicate a corresponding level of economic return.

The research hypothesis was confirmed. The contribution of creative industries is multidimensional and cannot be objectively assessed using a single indicator. In 2022–2023, relatively high values of the entrepreneurial and export components were accompanied by a substantial deterioration in economic performance. This provides grounds for arguing that the resilience of the sector should be assessed not only by the number of active business entities or the maintenance of exports, but also by their capacity to generate economic outcomes, provide employment, and increase labour productivity.

The comparison of the 2020 and 2023 results is particularly revealing. The values of the composite index in these years were almost identical (see *Table 2*), but they resulted from different combinations of the sub-indices. In 2020, the economic and labour components were higher, whereas in 2023 the entrepreneurial and export components were higher. Thus,

similar values of the composite index may characterise different states of the sector. Therefore, the composite index should be used only in conjunction with an analysis of the sub-indices, which makes it possible to identify the sources of change and reveal internal imbalances.

The structural heterogeneity of creative industries also requires particular attention. In 2024, *IT* and information services, together with advertising and communications, accounted for 83.5% of the sector's total sales. At the same time, cultural, artistic, and certain professional activities demonstrated considerably lower economic performance. Overall, this indicates that aggregate sector indicators depend to a large extent on the performance of digital and commercially oriented activities and do not fully reflect the state of its other components.

The scientific novelty of the findings lies in the further development of a methodological approach to assessing the contribution of creative industries based on the combination of entrepreneurial, economic, labour, and export components. The proposed approach makes it possible not only to identify the overall dynamics of the sector, but also to determine the causes of changes in the composite index and to distinguish between the quantitative preservation of activity and genuine economic recovery. The practical application of the methodology may be useful for monitoring creative industries and assessing the effectiveness of national and regional programmes supporting creative industries. In our view, the principal criterion for the effectiveness of such programmes should be not an increase in the number of business entities, but an enhancement of their capacity to create, commercialise, and scale creative products.

Further research should focus on expanding the information base for the assessment, in particular by incorporating indicators of gross value added, innovation activity, the use of intellectual property assets, regional concentration, and non-formalised forms of employment. It is also important to conduct regional analysis, test the sensitivity of the results to changes in the weights assigned to the sub-indices, and update the methodology following Ukraine's transition to the NACE 2.1-UA classification.

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INSTITUTIONAL CONSTRAINTS ON THE DIGITAL TRANSFORMATION OF UKRAINIAN AGRICULTURAL SECTOR

This study investigates the theoretical and methodological foundations and tools of digital transformation in Ukraine's agricultural sector and develops scientific and methodological approaches to establishing a system of indicators for assessing agricultural digital maturity in the context of sustainable development and European integration. The hypothesis is put forward that the effectiveness of digital transformation is determined not so much by the level of implementation of individual digital technologies as by the coherence of organisational, economic, technological, and institutional tools that ensure their integration into the agricultural sector management system. The hypothesis was tested through the systematisation of scientific approaches to the digitalisation of agricultural production, comparative and structural-functional analysis, assessment of the relationships between digitalisation indicators, innovation potential, and sustainable development, and an examination of official statistical data, European Commission materials, and international indices, including the Global Innovation Index and the Digital Economy and Society Index. It was established that the digital transformation of the agricultural sector is a comprehensive process encompassing the use of precision agriculture technologies, sensor and satellite monitoring, the Internet of Things, Big Data, artificial intelligence, geographic information systems, unmanned technologies, and digital management platforms. Indicators for assessing

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ІНСТИТУЦІЙНІ ОБМЕЖЕННЯ ЦИФРОВОЇ ТРАНСФОРМАЦІЇ АГРАРНОГО СЕКТОРУ УКРАЇНИ

Досліджено теоретико-методологічні засади та інструментарій цифрової трансформації аграрного сектору України, а також розроблено науково-методичні підходи до формування системи показників оцінювання рівня цифрової зрілості аграрної сфери в контексті сталого розвитку та європейської інтеграції. Висунуто гіпотезу, що результативність цифрової трансформації визначається не стільки рівнем упровадження окремих цифрових технологій, скільки узгодженістю організаційних, економічних, технологічних та інституційних інструментів, що забезпечують їх інтеграцію у систему управління аграрним сектором. Перевірку гіпотези здійснено шляхом систематизації наукових підходів до цифровізації аграрного виробництва, порівняльного та структурно-функціонального аналізу, оцінювання взаємозв'язків між показниками цифровізації, інноваційного потенціалу та сталого розвитку, а також аналізу офіційних статистичних даних, матеріалів Європейської комісії та міжнародних індексів, зокрема Global Innovation Index і Digital Economy and Society Index. Встановлено, що цифрова трансформація аграрного сектору є комплексним процесом, який охоплює використання технологій точного землеробства, сенсорного та супутникового моніторингу, Internet of Things, Big Data, штучного інтелекту, геоінформаційних систем, безпілотних технологій і цифрових платформ управління. Систематизовано показники оцінювання цифрової

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digital transformation were systematised into technological, economic, environmental, social, and institutional blocks, enabling a comprehensive assessment of the level of digital maturity of the agricultural sector and the effectiveness of digital solutions implementation. Technological heterogeneity of the agricultural sector was identified, manifested in a significant gap between digitally mature large enterprises and small and medium-sized producers with limited access to digital infrastructure, financial resources, and modern digital competencies. Methods and tools for digital transformation were systematised according to organisational, economic, technological, and institutional criteria. The feasibility of their integrated application was substantiated to ensure the relationship between digital modernisation and increased efficiency of agricultural production. The proposed approach can be used to improve state digitalisation policy, substantiate priorities for supporting agricultural enterprises, and monitor the effectiveness of digital transformation in Ukraine's agricultural sector.

Keywords: digital transformation, agricultural sector, digital platforms, sustainable development, innovation system.

трансформації за технологічним, економічним, екологічним, соціальним та інституційним блоками, що дає змогу комплексно визначати рівень цифрової зрілості аграрного сектору та результативність упровадження цифрових рішень. Виявлено технологічну неоднорідність аграрного сектору, що проявляється у значному розриві між цифрово зрілими великими підприємствами та малими й середніми виробниками з обмеженим доступом до цифрової інфраструктури, фінансових ресурсів і сучасних цифрових компетентностей. Систематизовано методи та інструменти цифрової трансформації за організаційною, економічною, технологічною та інституційною ознаками. Доведено доцільність їх комплексного застосування для забезпечення взаємозв'язку між цифровою модернізацією, підвищенням ефективності аграрного виробництва. Запропонований підхід може бути використаний для вдосконалення державної політики цифровізації, обґрунтування пріоритетів підтримки аграрних підприємств і моніторингу результативності цифрової трансформації аграрного сектору України.

Ключові слова: цифрова трансформація, аграрний сектор, цифрові платформи, сталий розвиток, інноваційна система.

JEL Classification: Q16, O33, O32.

Introduction

Ukraine's agricultural sector is going through a massive digital shift. Right now, adopting new technology isn't just a trend; it's actually become essential for keeping farms profitable and making sure they can access European markets (Mamchur et al., 2025; Mamchur & Studinska, 2024). Digital transformation helps connect data that used to be isolated, bringing together things like field telemetry, weather patterns, and financial analytics. This integration allows farm managers to make decisions based on solid data instead of just going by gut feeling. However, national strategies still tend to treat digitalization as an extra tool rather than a main driver of economic growth, which keeps holding back long-term development (Mishchenko, 2024).

Changing the agricultural landscape is a bit of a balancing act. Policymakers have to align regional and national goals, protect food supply chains, and update domestic rules to meet strict European Union standards (Mamchur et al., 2025; Huyen et al., 2025; Ye, 2025). This brings up a major question: how do we actually measure the real impact of digital adoption? Right now, Ukraine's statistical framework only gives us a partial picture. It doesn't really capture the full depth of these digital shifts, and it's completely out of sync with EU evaluation standards like DESI or PMEF (Rudenko, 2019; Huyen et al., 2025). Without standardized metrics, it's impossible to compare progress

against EU benchmarks, which causes public policy to lose focus and makes foreign investors hesitant (Mamchur et al., 2025; Li et al., 2025). Because of this, updating these evaluation methods has become an urgent priority (AgroTimes, 2021; Aros et al., 2025; European Commission, n. d.).

Research into agricultural innovation and sustainability is built on a deep academic foundation. Scholars like B. M. Danylyshyn, M. I. Dolishniy, S. I. Dorohuntsov, M. F. Kropyvko, H. M. Kaletnik, S. V. Kozlovskyi, L. V. Melnyk, Ye. V. Mishenin, M. M. Palamarchuk, V. M. Trehobchuk, P. T. Sabluk, and O. H. Shpykuliak established the groundwork regarding sector dynamics, institutional capacity, and public policy. More recent studies build on this by showing how public institutions and regulatory frameworks drive agricultural progress (Mamchur et al., 2025; Mamchur & Studinska, 2024; Ministry of Agrarian Policy and Food of Ukraine, n. d.; Ye, 2025).

On an international level, experts see digitalization as much more than just upgrading software or machinery. It's viewed as a systemic institutional shift that changes how businesses operate and makes them more agile. Global studies look at how digital tools support sustainable growth (Bilochenko et al., 2020; European Commission, 2021; Ferla, et al., 2024; Huyen et al., 2025) and how they help shape policy monitoring tools within the EU (Rudenko, 2019; AgroTimes, 2021; Aros et al., 2025). Researchers are even creating composite indices to measure digital readiness while staying aligned with the Sustainable Development Goals and the European Green Deal (Bilochenko et al., 2020).

Even with all this theory, there's still a big gap in the Ukrainian literature. While local studies often talk about general digitalization strategies, very few actually look at how to practically align national metrics with EU benchmarks (Ivantsov, 2024). We're still missing comprehensive research that measures how efficient digital tools actually are using EU-compatible indicators that are specifically tailored to Ukraine's unique regional conditions (Mamchur et al., 2025).

The aim of this study is to theoretically ground the digital tools transforming Ukraine's agricultural sector while designing an indicator system to track digital progress against sustainability and EU integration benchmarks.

The study operates on the hypothesis that digital transformation's success isn't just about adopting new tech, but about how well organizational, economic, technological, and institutional tools are aligned. To test this, the research uses a mix of scholarly analysis, official statistics, European Commission data, and international indices through comparative and systems analysis.

The article is organized into three main parts. First, it looks at the theoretical foundations of agricultural digital transformation. Second, it discusses the key components of sustainable agricultural development in a

digital age. Third, it develops the methodological tools for this transformation. This third section specifically looks at the organizational and territorial hurdles to adopting digital tools, the economic and technological factors at play, priority areas for growth, and a comparison between digital strategies in the EU and Ukraine.

1. Theoretical and methodological foundations of agricultural digital transformation

Digitalization is changing the way agricultural enterprises organize production, manage resources, and interact with markets. These changes concern not only the introduction of new technologies but also the revision of established management practices, approaches to production planning, and relationships between participants in agricultural value chains (Ferla et al., 2024; Ivantsov, 2024). Precision farming, big data analytics, artificial intelligence, the Internet of Things (IoT), and digital management platforms are increasingly used to monitor agricultural operations, assess production conditions, and process information from different sources (Mamchur & Studinska, 2024). The availability of such information enables enterprises to assess the relationship between production costs, resource consumption, environmental conditions, and expected output when making management decisions. It also helps identify potential production risks at an earlier stage (Rudenko, 2019; Li et al., 2025). Previous technological developments in agriculture mainly involved the mechanization of physical operations and the computerization of specific management functions. In contrast, technologies associated with Industry 4.0 allow data from machinery, sensors, production records, and management systems to be processed and used together (Mamchur et al., 2025; Mishchenko, 2024; Huyen et al., 2025). Their application can improve the accuracy of production planning, reduce losses of materials and other inputs, and support more efficient use of labor, equipment, and agricultural resources. The extent of these improvements, however, depends on the compatibility of the technologies introduced, the quality of available data, and the capacity of enterprises to incorporate analytical results into their everyday operations.

1.1. Methods and tools of agricultural digitalisation in the context of European integration

Agricultural enterprises apply digital technologies in different ways. Much depends on the size of the farm, its financial capacity, technical equipment, and production needs. Some enterprises use digital systems to monitor field conditions. Others focus on production planning, cost control, or the management of agricultural machinery. The methods also differ in their

complexity and the amount of data required. Several approaches can be distinguished:

- monitoring methods involve collecting information from field sensors, satellite images, and unmanned aerial vehicles. These technologies are used to examine soil conditions, observe crop development, and monitor agricultural machinery. The collected data help farmers identify changes in field conditions and decide when specific operations are needed (Mamchur & Studinska, 2024; European Commission, n. d.);
- analytical methods rely on statistical models, machine learning, and artificial intelligence. They are used to estimate crop yields, examine weather-related risks, and compare possible farming decisions. The accuracy of such estimates depends on the quality of the input data. Incomplete records and differences between growing seasons may affect the results (Ivantsov, 2024; Ye, 2025);
- digital management platforms are used to organise information about farm activities. Production records, machinery schedules, logistics, and financial data can be maintained within the same system. This reduces the need to process information from several unrelated sources. It also makes it easier to compare planned activities with actual results (Mamchur et al., 2025);
- digital traceability methods are concerned with recording transactions and product movements. Blockchain is one of the technologies that can be used for this purpose. It allows information about individual operations to be stored in a form that can be checked by authorised participants. Such records are useful when agricultural products pass through several stages of processing and distribution (Pomirna, 2015).

The use of these methods does not produce identical results across agricultural enterprises. A large farm may have the resources to maintain its own digital infrastructure and employ specialists to analyse production data. A smaller producer may rely on basic software or services provided by external companies. Internet access, equipment costs, and employee qualifications also influence the choice of technologies. These differences are especially important when examining agricultural digitalisation in Ukraine. The country's closer economic cooperation with the European Union has increased the importance of agricultural data management, environmental reporting, and product traceability (European Commission, n. d.; Huyen et al., 2025).

Evaluating digitalisation requires more than identifying which technologies are available. The presence of specialised software does not necessarily mean that it is used regularly. The same applies to sensors, automated equipment, and digital platforms. An enterprise may purchase such tools but continue making most decisions through conventional procedures. For this reason, the assessment should consider both technology adoption and its actual use. Changes in production costs, labour requirements, resource consumption, and management practices are also relevant.

Several groups of indicators can be used for this purpose. Technological indicators describe the availability of equipment, communication networks, and digital services. Economic indicators concern investment costs, productivity, and the financial results of technology use. Environmental indicators may include water consumption, fertiliser application, and energy use. Social indicators describe employees' digital skills and access to technological services in rural communities. Institutional indicators concern public information systems, regulatory requirements, and the exchange of agricultural data. These groups should be examined together, although each measures a different aspect of digitalisation.

The European Union provides a useful reference for such an assessment. Agricultural Policy in EU member states is organised within the Common Agricultural Policy (CAP). Its objectives extend beyond increasing agricultural output. They also concern farm incomes, market competitiveness, environmental conditions, climate-related issues, and the development of rural communities. Digital technologies are relevant to several of these objectives, but they are not equally important in every area. Their role depends on the problems being addressed and the conditions under which agricultural enterprises operate (European Commission, n. d.; Huyen et al., 2025).

For instance, data collected through precision farming systems can be used to examine changes in fertiliser and water consumption. Digital accounting systems provide information about operating costs and financial performance. Electronic records of product movement can support traceability within food supply chains. These examples concern different aspects of agricultural activity. They cannot be evaluated using the same indicators alone. A reduction in resource consumption, for example, describes a different outcome from improved access to production records.

The EU uses established monitoring and evaluation procedures to examine the implementation of agricultural policy. The Common Monitoring and Evaluation Framework (CMEF) was developed for this purpose. For the 2023–2027 CAP period, the relevant system is the Performance Monitoring and Evaluation Framework (PMEF). These frameworks contain indicators covering different policy objectives and results. However, many of the indicators do not measure digital technology adoption directly. Instead, they describe changes in agricultural production, environmental conditions, or rural development. When analysing digitalisation, it is therefore necessary to distinguish between indicators of technology use and indicators of outcomes that may be influenced by that use. *Table 1* presents selected CAP indicators alongside the areas of agricultural digitalisation to which they are related.

Table 1

Relationships between EU Common Agricultural Policy indicators and agricultural digital transformation

CAP priority	Manifestations of digitalisation	Key digital indicators
Sustainable development and green practices	Precision farming systems; satellite and sensor monitoring	Share of farms using digital soil and yield monitoring systems
Innovation and knowledge	EIP-AGRI projects; digital innovation hubs	Number of digital innovation projects under the CAP
Competitiveness and efficiency	*Big data; IoT; automated resource accounting*	Labour productivity on digitally active farms
Social cohesion and rural development	Online platforms; digital advisory services	Share of farmers with high-speed internet access
Climate neutrality	*Copernicus; GIS technologies*	Extent of digital land-use monitoring

Source: systematised by the author based on European Commission (n. d.) and Huyen et al. (2025).

To examine agricultural digitalisation in relation to sustainable development and the EU Common Agricultural Policy, a set of indicators is proposed. The indicators cover five areas: technological, economic, environmental, social, and institutional. Each area addresses a different aspect of change in agricultural enterprises. Some indicators describe the availability and use of digital technologies. Others concern their economic results, environmental effects, or the conditions needed for their wider adoption. This distinction is important because the installation of digital equipment does not always lead to measurable improvements in farm performance.

The technological dimension concerns the extent to which digital tools are used in agricultural production and management. It includes the following indicators:

- the proportion of agricultural enterprises applying precision farming methods;
- the use of IoT devices, geographic information systems (GIS), large-scale data processing, and automated farm management software;
- the proportion of production and logistics operations supported by digital systems;
- the availability and quality of internet connections in rural areas.

The economic dimension focuses on the costs and results of introducing digital technologies. Particular attention is given to whether these technologies improve farm operations and justify the resources invested in them. The indicators include:

- labour productivity at farms that regularly use digital technologies;
- financial returns relative to the cost of digital equipment and software;
- the amount of private and public investment directed towards agricultural technologies;

• the proportion of agricultural exports covered by digital product traceability systems.

• the environmental dimension examines how digital technologies are used to manage natural resources and reduce the environmental effects of agricultural production. Four indicators are considered:

• the area of agricultural land monitored using digital mapping and observation systems;

• changes in fertiliser and pesticide consumption associated with precision application technologies;

• changes in CO_2 emissions resulting from adjustments to agricultural operations;

• the proportion of farms using electronic systems to monitor environmental conditions.

The social dimension concerns the people who use agricultural technologies and the opportunities available to rural communities. Purchasing new equipment is only one part of digitalisation. Farm employees also need the knowledge required to operate it, interpret the information collected, and apply the results in their work. The proposed indicators are:

• the level of digital skills among farmers and agricultural employees;

• the proportion of workers who have completed training in the use of digital technologies;

• the availability of high-speed internet services in rural settlements;

• the number of advisory services providing practical assistance with agricultural digital tools.

The institutional dimension addresses the regulatory and organisational conditions under which agricultural digitalisation takes place. This area is particularly relevant to Ukraine because national agricultural practices and information systems need to be considered in relation to EU requirements. The indicators include:

• the extent to which Ukrainian agricultural legislation corresponds to relevant EU regulations;

• participation in agricultural innovation and cooperation programmes, including EIP-AGRI and applicable CAP-related initiatives;

• the amount of government funding allocated to agricultural digitalisation;

• the adoption of data protection and cybersecurity measures in agricultural information systems.

The five groups of indicators provide different types of information. They should not be interpreted as interchangeable measures. For example, the number of farms using precision agriculture equipment describes technology adoption, whereas changes in fertiliser consumption may indicate one of its practical effects. Similarly, investment in agricultural software does not automatically demonstrate higher productivity. These relationships need to be examined using comparable data and, where possible, observations over several years.

The proposed indicators can be used to compare agricultural enterprises, regions, and changes over time. They can also help identify where digital development is uneven. One region may have relatively good internet coverage but limited use of farm management systems. Another may show substantial investment in agricultural technologies while having relatively few trained employees. Such differences are important for selecting public support measures and assessing their results. In the Ukrainian context, the indicators also provide a basis for examining the relationship between agricultural digitalisation, sustainable resource use, and the requirements associated with European integration.

1.2. The role of innovation potential in agricultural digitalisation

The Global Innovation Index (GII) can also be used when examining agricultural digitalisation. It provides information about the conditions that influence the development and use of new technologies in different countries. These include the quality of institutions, access to infrastructure, education, research activities, and investment. Such conditions matter for agriculture as well. Farms need reliable communication networks, skilled employees, and financial resources to introduce digital equipment and software. However, a country's position in the GII does not necessarily show how widely these technologies are used in its agricultural sector. The index describes the broader innovation environment, while sector-specific indicators are needed to examine what happens at the farm level. Comparing the two can help identify differences between national innovation capacity and the actual use of digital technologies in agriculture. *Table 2* presents the main groups of GII indicators and their relationships with agricultural digitalisation, including technical infrastructure, workforce skills, innovation activities, and public support.

Table 2

Relationships between Global Innovation Index indicators and agricultural digitalisation

GII indicator group	Examples of GII indicators	Related indicators of agricultural digitalisation	Area of relationship
Infrastructure	ICT access; ICT use; e-government	Rural digital connectivity; use of GPS, IoT, and drones	Technological foundation of digitalisation
Human capital and research	Quality of education; number of researchers; education expenditure	Farmers' digital literacy; AgriTech programmes	Workforce training
Business sophistication	R&D investment; business–research collaboration	Joint projects between agricultural companies and IT start-ups	Innovation ecosystem
Market sophistication	Access to finance; venture capital	Investment in digital farms and AgriTech start-ups	Financial provision

End of Table 2

GII indicator group	Examples of GII indicators	Related indicators of agricultural digitalisation	Area of relationship
Institutional environment	Government effectiveness; regulatory quality	Government programmes for agricultural digitalisation	Government support
Knowledge and technology outputs	Patents; high-technology exports	Precision farming developments	Effectiveness of digital innovation

Source: systematised by the author using data from Rudenko (2019) and Aros et al. (2025).

The adoption of digital technologies in agriculture depends on the technical and economic conditions in which farms operate. New software or equipment cannot always be introduced into existing production systems without additional investment. Farms may first need to improve their communication networks, replace outdated machinery, or train employees. The level of technological development can therefore be examined through several indicators. These include the automation of production processes, the use of ICT, precision farming equipment, ERP systems, and data analytics. Research expenditure, investment in AgriTech, broadband coverage, and access to digital management services are also relevant. Together, these indicators describe the resources available for digitalisation and the extent to which they are already used in agricultural activities (Mamchur & Studinska, 2024; Ferla, et al., 2024).

However, technological development differs considerably across the agricultural sector. Large agricultural holdings often have better access to capital, equipment, and technical expertise. Many already use satellite imagery to monitor fields, sensors to collect production data, and specialised software to coordinate machinery and logistics. Some have introduced digital systems across several stages of production, from field planning to product distribution. Smaller farms operate under different conditions. The cost of equipment may be too high relative to their production scale. Maintaining specialised software also requires money and qualified personnel. As a result, digital technologies may be used only for individual tasks, such as accounting, field mapping, or machinery monitoring. This does not mean that all small farms have low technological capacity. Their level of digitalisation varies according to specialisation, available resources, and management decisions.

These differences should be considered when assessing the technological development of agriculture as a whole. A sector-wide average can conceal substantial variation between enterprises. For example, a relatively small number of technologically advanced agricultural holdings may account for a considerable share of production, while many smaller producers continue to use conventional management methods. The resulting

average depends on whether enterprises are weighted by their number, agricultural area, output, or employment. The choice of measurement therefore matters. A low average level of digitalisation does not necessarily describe every farm. Equally, the presence of several highly automated enterprises does not indicate that similar technologies are widely available throughout the sector.

Differences in technological capacity also affect the pace of further digitalisation. Farms with existing information systems can often introduce additional applications without making major changes to their infrastructure. Enterprises that lack reliable internet access, compatible machinery, or digital records face more difficulties. They may need to address these basic requirements before adopting more complex technologies. For this reason, support measures should take account of the actual conditions in different groups of agricultural enterprises. Smaller producers may benefit from shared digital services, affordable equipment, training, and technical advice. Rural broadband development remains important, particularly in areas where limited connectivity restricts the use of online platforms and remote monitoring. Cooperation between agricultural producers, technology companies, and research institutions can also make specialised solutions more accessible (Rudenko, 2024; Aros et al., 2025; Ferla et al., 2024).

A uniform approach to agricultural digitalisation would overlook these differences. The same investment or support measure may produce different results depending on a farm's initial technological capacity. For some enterprises, the main requirement is access to basic digital infrastructure. Others need assistance with integrating existing systems or processing the data they already collect. Public policy should therefore distinguish between these needs. Such differentiation would allow resources to be directed towards specific technological constraints rather than treating the agricultural sector as a group of enterprises with similar levels of digital development.

2. Key components of sustainable agricultural development and prerequisites for digital transformation

Agricultural sustainability is shaped by the conditions under which farms produce, invest, and manage their resources. Higher output alone does not indicate that an enterprise is developing sustainably. A farm may increase production while facing rising operating costs, declining soil quality, or shortages of qualified employees. These problems require different responses. Digital technologies can help with some of them, particularly where decisions depend on accurate information about production, finances, and natural resources. Their usefulness should be judged by the results obtained in everyday farming activities.

For agricultural producers, economic stability largely depends on the relationship between production costs, output, and market prices. Investment in machinery and software may improve labour productivity or reduce unnecessary expenditure. Yet these benefits are not guaranteed. The costs of purchasing equipment, maintaining software, and training employees must also be considered. Environmental issues present another set of concerns. Soil degradation, inefficient water use, and excessive application of fertilisers can affect future production. Digital field monitoring and automated application systems allow farmers to adjust certain operations according to local conditions. This may reduce resource consumption, although the outcome depends on the technology selected and the way it is operated (Mamchur & Studinska, 2024; *Ye*, 2025).

Conditions in rural communities influence agricultural development as well. Modern equipment requires technical knowledge. Employees must be able to work with electronic records, understand information from monitoring systems, and respond to equipment faults. Such skills are not equally available across farms. Smaller enterprises may find it difficult to employ dedicated technical specialists or pay for additional training. Poor internet connectivity creates further limitations. In these circumstances, local advisory services can provide assistance with equipment selection, digital applications, and agricultural regulations. Their work is particularly useful when advice addresses specific problems faced by producers rather than offering general information about new technologies.

Agricultural investment also depends on the rules and financial arrangements within which enterprises operate. Access to credit, the availability of public support, and the clarity of regulatory requirements can influence whether farms decide to introduce new technologies. This is relevant to Ukraine as agricultural producers adjust to European standards. Compliance may require changes in record keeping, product documentation, and environmental reporting. Larger enterprises can often assign these tasks to specialised departments. Smaller farms may need external assistance. The availability of advisory organisations and accessible public information therefore has practical importance for the implementation of regulatory changes (Mamchur & Studinska, 2024).

The organisation of farm management is another factor. Digital equipment produces little benefit when the information it collects is not used. Field observations, machinery records, and financial data need to be reviewed and incorporated into production planning. This requires employees with suitable qualifications and managers willing to adjust established procedures. Cooperation with research institutions, software developers, and equipment suppliers can help farms solve technical problems. Joint projects involving public authorities and private enterprises may also support infrastructure development and professional training. Their

effectiveness depends on the needs of participating producers and the resources available for implementation (Ivantsov, 2024; Mamchur & Studinska, 2024; Ye, 2025).

The spread of new agricultural practices is also influenced by relationships between producers. Farmers exchange experience, discuss equipment performance, and obtain information through professional associations and local networks. These contacts can reduce uncertainty when an enterprise considers an unfamiliar technology. They are especially valuable in communities where access to specialised advice is limited. Regional differences in infrastructure, employment, education, and business cooperation therefore need to be considered when examining agricultural digitalisation. The same technological solution may be useful in one locality and difficult to apply in another. This makes local economic and social conditions an important part of assessing changes in agricultural production (Pomirna, 2015).

2.1. Components of sustainable agricultural development

Sustainable development in agriculture concerns three areas: environmental protection, economic stability, and social conditions. Each has its own priorities, although changes in one area often affect the others. Agricultural production depends on natural resources, financial opportunities, and the people involved in farming. For this reason, these three areas need to be considered together.

The environmental aspect concerns the condition of agricultural land, water resources, and surrounding ecosystems. Farming practices should limit soil degradation, unnecessary water consumption, and pollution without compromising production needs. Biodiversity conservation and adaptation to changing climatic conditions are also important. Digital technologies can assist with these tasks. For example, precision farming equipment allows fertilisers and water to be applied according to field conditions. Monitoring systems provide information about soil moisture, crop development, and resource consumption. Farmers can use these data to adjust their operations and avoid unnecessary expenditure on inputs.

The economic aspect concerns the ability of agricultural enterprises to maintain profitable production over time. This depends on operating costs, labour productivity, access to investment, and market conditions. Digital tools can be useful in managing these factors. Farm management software helps organise production records and financial information. Automated equipment may reduce the time required for certain operations. Data analysis can also support decisions about purchasing resources, scheduling agricultural work, and selling products. However, the financial results depend on the scale of production, initial investment, and the actual use of the technologies introduced.

The relationships between these three aspects are presented in *Figure 1*.

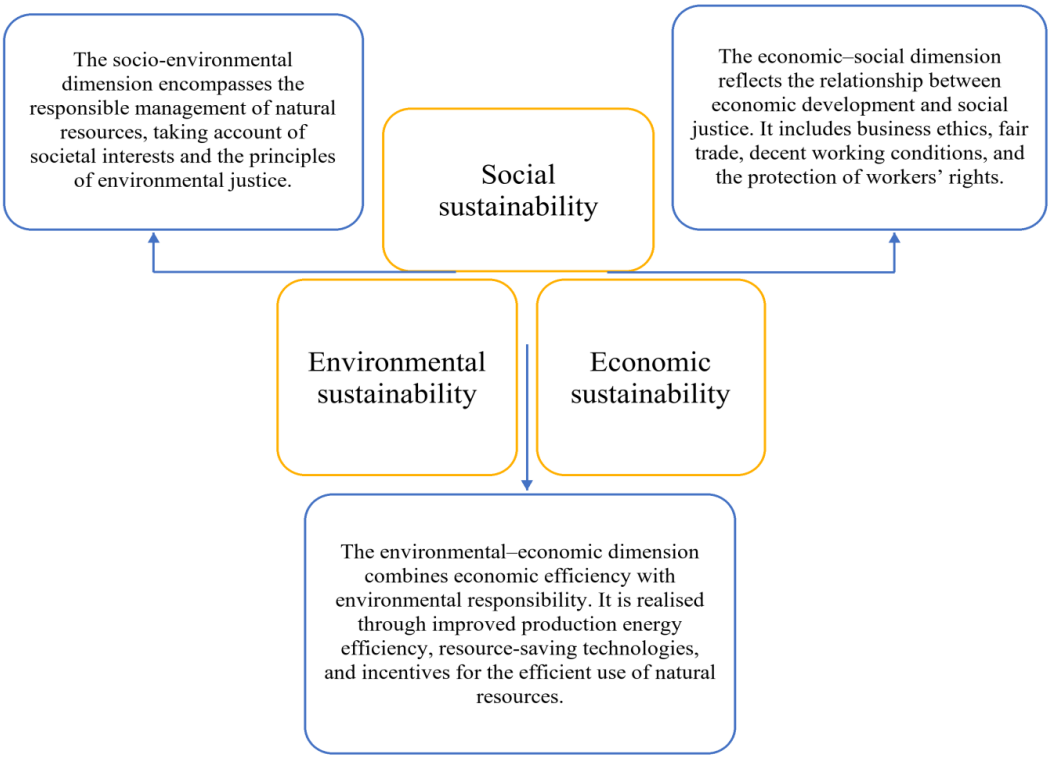


Figure 1. Structural interaction of sustainable agricultural development components

Source: compiled by the author based on Prokopenko (2024) and Olawale et al. (2024).

The social side of things involves jobs, professional skills, and what it is actually like to live in rural areas. As technology changes, the skills needed for agricultural work change too. Some jobs are being taken over by machines, while others now require a solid grasp of digital tools and information systems. Because of this, getting access to training is vital, especially for people working on smaller farms. On top of that, gaps in internet access and education can make inequalities between rural communities even worse. We really need to focus on groups that struggle to access jobs, technology, or basic public services. It also helps to involve local residents in development decisions so their needs are weighed alongside the economic goals of big agricultural businesses.

It is also worth noting that environmental, economic, and social goals don't always line up. For example, pushing for higher crop yields can put a lot of strain on soil and water. On the flip side, environmental regulations can drive up costs, which is especially hard on farms that don't have much extra cash. Even technology can be a double-edged sword; it might boost productivity, but it also changes what kind of jobs are available in the countryside. Since these goals often pull in different directions, it is hard to pursue all of them at once. Agricultural development requires making tough

calls that account for these trade-offs, the resources on hand, and the unique situation of each farm.

Digital tools can actually help farmers make better decisions by using data from their own production. Field monitoring can show exactly how soil and crops are doing, while management software makes it easy to track costs and resource use over time. These tools can point out where things are being wasted or where farming methods need to change. However, technology only helps with sustainability if that information actually leads to real-world changes. Just installing a new digital system isn't enough on its own.

There are still several big hurdles facing the future of agriculture. Soil degradation is lowering productivity, unpredictable weather makes planning a nightmare, and water shortages combined with rising costs are putting a lot of financial pressure on farmers. At the same time, uneven access to income, infrastructure, and technology means not all producers are starting from the same place. These issues are all linked, but there is no single solution that fixes everything. Their importance also changes depending on the region and the type of farming being done.

Moving forward, changes in farming should balance environmental needs with the economic reality of the producers. This could mean moving toward agroecological methods, better soil conservation, smarter water management, or practices that fit local climates. Small and medium-sized farms, in particular, might need better access to loans, technical advice, and shared services. Public support should also recognize that a tiny farm and a massive operation have very different needs. Digital systems can be great for monitoring results and managing records, but they work best when they are used to solve specific, practical problems rather than just being used for the sake of modernization.

2.2. Factors shaping the initiation of agricultural digital transformation

An examination of the fundamental factors shaping the initiation of agricultural digital transformation allows them to be grouped into four principal categories: the sector-specific characteristics of agricultural production, its territorial conditions, the development of the agricultural innovation system, and the specific features of the sector's information provision (*Figure 2*). A closer examination of these groups shows that:

- broadband internet coverage in rural areas is substantially lower than in urban areas because of the high cost of developing telecommunications infrastructure where farms are spatially dispersed and population density is low. This limits producers' integration into digital platforms and their access to cloud services and data analytics systems. These observations are consistent with the approaches to assessing digital development used in the Digital Economy and Society Index (DESI), where connectivity and digital skills are key determinants of economic digitalisation;

• the share of small and medium-sized farms using precision farming systems remains limited owing to the high capital intensity of digital solutions, long investment payback periods, and restricted access to finance. This creates a technological asymmetry between large agricultural holding companies and small producers, reflecting the imbalances in innovation development captured by the GII, particularly its "business sophistication" and "knowledge and technology outputs" pillars;

• agricultural R&D investment is unstable because of insufficient interaction between research institutions and businesses and the low commercialisation of research findings. This reduces the effectiveness of technology transfer and slows the adoption of innovations in production. These constraints are reflected in countries' positions on GII indicators that describe the innovation ecosystem and the effective use of research potential;

• the shortage of digital technology specialists in rural areas results from the migration of skilled workers, limited access to quality education, and an insufficiently developed AgriTech training system. This complicates both the adoption and the effective use of digital tools. Within DESI, this problem correlates with "human capital" indicators, which capture the population's digital skills as a key prerequisite for digital transformation.

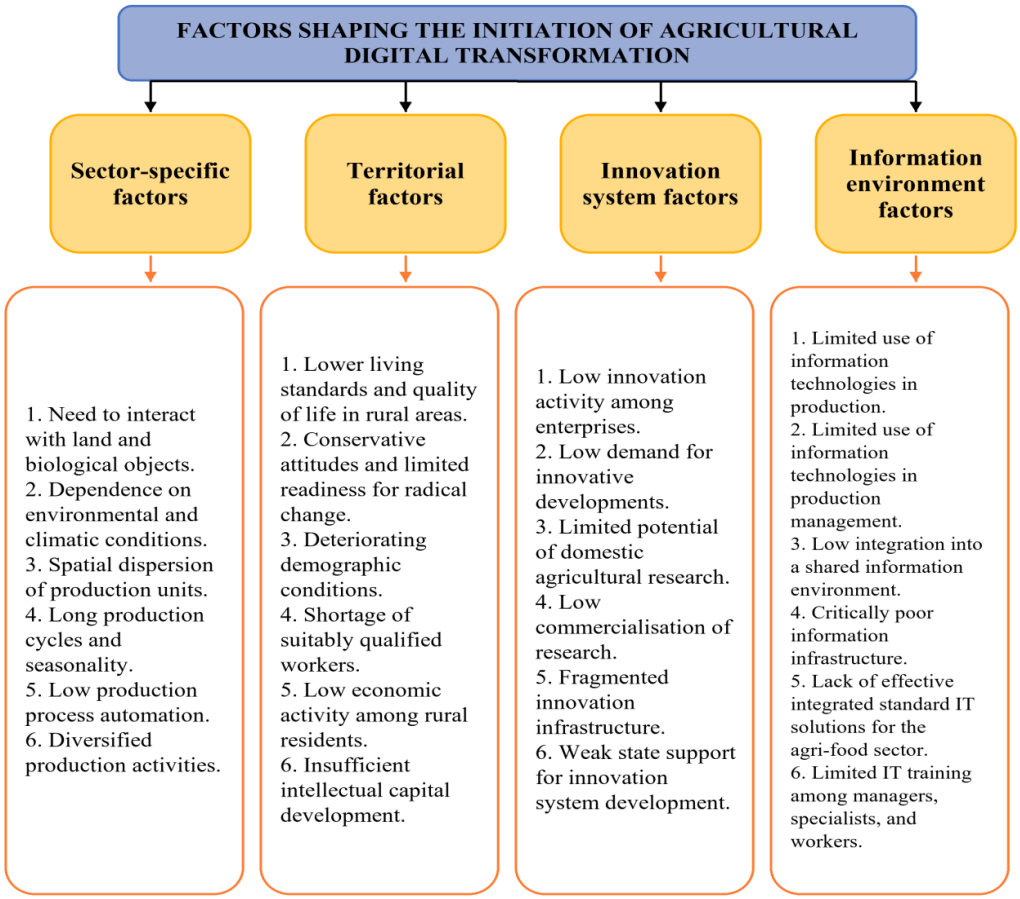


Figure 2. Factors shaping the initiation of agricultural digital transformation

Source: compiled by the author based on Mamchur et al. (2025) and Ivantsov (2024).

Agriculture's strong dependence on environmental and climatic factors, particularly temperature fluctuations, soil moisture, and seasonal production patterns, further increases the need for digital solutions. Real-time agrometeorological monitoring, digital yield forecasting, and automated risk management can reduce uncertainty in production processes, improve the adaptability of agricultural production, and enable more efficient resource use.

3. Methodological foundations and tools of agricultural digital transformation

The methods used in agricultural digitalisation differ in their purpose and practical application. For further analysis, they are divided into four groups: organisational, economic, technological, and institutional. Section 1.1 examined the main approaches to digitalisation and the indicators used to assess their application. The present section focuses on how these methods are introduced into agricultural activities and how they relate to sustainable development objectives and Ukraine's integration with the European Union. The proposed classification is presented in *Table 3* (Mamchur et al., 2024; Ivantsov, 2024).

Table 3

Classification of methods and tools of agricultural digital transformation

Category	Characteristics	Principal tools
Organisational	Transform management systems and the organisation of production processes	Business process re-engineering; digital farm management platforms; value chain integration; agricultural clusters
Economic	Provide financial and economic incentives and assess digitalisation effectiveness	Government support programmes; grants; subsidies; public–private partnerships; methods for assessing economic effects
Technological	Provide the technological foundation for digital transformation	Precision farming; IoT; big data; artificial intelligence; GIS; unmanned technologies; automated systems
Institutional	Create the regulatory and organisational environment for digitalisation	National digital development strategies; harmonisation with EU requirements; information and advisory centres; cybersecurity systems

Source: systematised by the author based on Mamchur et al. (2024) and Ivantsov (2024).

The results of applying different digitalisation methods can be examined using the indicators proposed earlier. Each group of methods concerns a particular area of agricultural activity. Technological methods are associated with the use of digital equipment, software, and automated production systems. Economic methods can be assessed through changes in labour productivity, operating costs, and returns on technological investment. Organisational methods concern how digital solutions are incorporated into farm management and everyday operations. Institutional methods relate to regulatory requirements, the adoption of European standards, and environmental obligations. Examining these relationships allows the proposed

indicators to be used not only to describe the level of digitalisation but also to assess changes associated with particular management decisions.

The classification also draws attention to the conditions under which agricultural enterprises introduce new technologies. The same method may produce different results depending on the type of production, farm size, and location. Agricultural activities are spread across large territories, often with uneven access to communication networks and technical services. Seasonal workloads and dependence on weather conditions create further difficulties. The availability of qualified employees also matters. Farms with established information systems and trained personnel can generally introduce additional digital applications more easily than enterprises that still rely on manual records and conventional equipment. These differences need to be considered when selecting digitalisation methods and evaluating their practical results.

3.1. Organisational and territorial constraints on digital tool adoption

The way agricultural production is spread out geographically makes digitalization quite a challenge. Fields, machinery, and storage sites are often far apart and frequently located in areas where internet coverage is spotty at best. Getting all these locations connected requires extra equipment and significant investment. This is especially tough for smaller farms, which usually have much tighter financial and technical resources to work with (Mamchur et al., 2024; Ivantsov, 2024).

Infrastructure needs also differ from one farm to the next. Some operations might need field sensors and satellite monitoring, while others are more focused on building communication networks or setting up independent power supplies. Ultimately, the costs depend on where the farm is located, how large it is, and what facilities are already in place. On top of that, limited access to technical support services makes things even harder (Rudenko, 2024; Aros et al., 2025; Ferla et al., 2024).

Data management is another major hurdle. Information like weather records, soil measurements, machinery logs, and transport schedules is often stored in separate silos. Because these different data formats don’t always play well together, analyzing them as a whole is difficult. Even when the data is accessible, it might not be in a format that can be used right away for production planning.

Seasonal production also makes investment decisions a bit of a gamble. The real benefits of adopting new technology might not show up until after a harvest or even after several growing seasons have passed. Plus, unpredictable weather and shifting market prices can impact financial returns. For smaller producers, this level of uncertainty often leads to delays in buying digital equipment (Rudenko, 2024; Ferla et al., 2024).

Farm management platforms can help solve some of these issues by bringing production schedules, machinery records, and logistics into one place. They allow managers to spot delays and adjust their operations on the

fly. However, their actual usefulness depends on having high-quality data and using the system consistently. Because of this, choosing the right technology has to be a careful process that considers a farm's specific needs, its infrastructure, and its budget (Ivantsov, 2024; Mishchenko, 2024).

3.2. Technological and economic factors in digital transformation

Agricultural businesses often juggle several different production activities at once, and each one needs its own specific equipment and management tools. Because of this, trying to integrate all these technologies can drive up digitalization costs by anywhere from 20 to 40 percent, based on recent estimates (Mamchur et al., 2025; Mishchenko, 2024; Li et al., 2025; Ye, 2025). Smaller farms, in particular, deal with much higher costs per hectare. When it comes to precision farming systems, the cost gap between small farms and large producers can be as much as 1.5 to 2 times higher. One way to ease this financial pressure could be through shared equipment and digital services (Mamchur et al., 2025; Li et al., 2025).

The actual results also depend on how these technologies are rolled out. Research shows that when digital solutions are applied across several production stages, productivity gains can hit 10 to 25 percent. On the other hand, using these tools in isolation only yields about 5 to 7 percent in improvements (Li et al., 2025; Ye, 2025). Still, widespread adoption is being held back by a few key issues, like poor cooperation between researchers and agribusinesses, a lack of commercialized innovations, and not enough funding. High upfront costs are still a major worry for small-scale producers. Depending on the specific technology and the size of the operation, it typically takes between three and seven years to see a return on these investments (*Table 4*).

Table 4

Quantitative manifestations of technological and economic factors in agricultural digital transformation

Factor	Quantitative manifestation	Economic consequences
Diversified production structure	Technology integration costs increase by 20–40%	Higher digitalisation costs and more complex implementation
Small farm scale	Costs per unit of area are 1.5–2 times higher	Reduced accessibility of digital technologies
Fragmented digitalisation	Productivity increases by only 5–7%	Limited effectiveness of isolated solutions
Comprehensive digitalisation	Productivity increases by 10–25%	Generation of systemic effects
Low commercialisation of innovation	Implementation lags by several years	Slower technological development
Financial constraints	More than 60% of producers cite high costs	Constrained investment
Long payback period	3–7 years	Reduced investment attractiveness

Source: systematised by the author based on Mishchenko (2024), Mamchur et al. (2025), Li et al. (2025), and Ye (2025).

Under these conditions, digital transformation requires both technological upgrading and effective economic mechanisms to reduce the costs of entering the digital environment. Particularly important are models for sharing digital technologies, platform-based solutions, expanded access to financial instruments, and incentives for public–private partnerships, consistent with European practices for supporting agricultural innovation.

3.3. Priority directions for agricultural digital transformation

The synthesis of the identified problems makes it possible to determine priority areas for agricultural digitalisation, which form the methodological foundation for the corresponding digital transformation methods and tools (*Figure 3*).

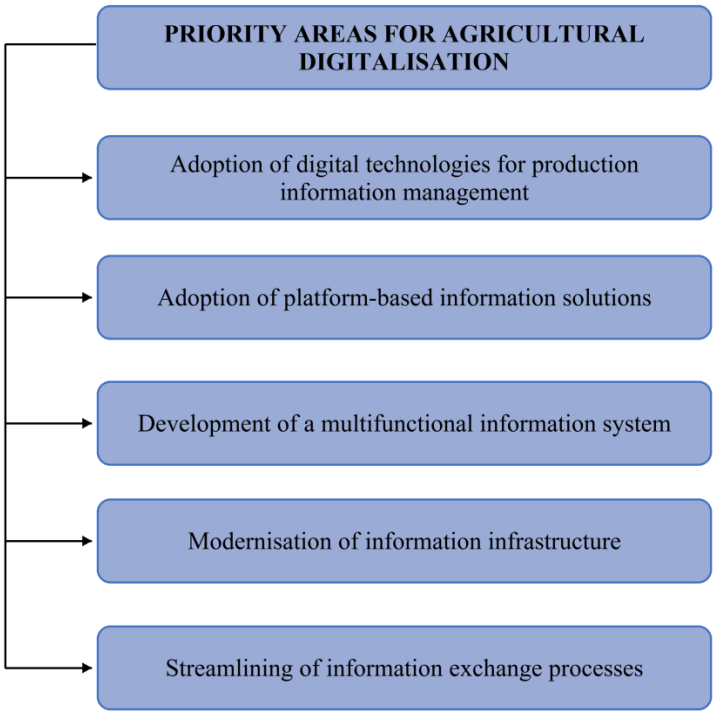


Figure 3. Key directions for agricultural digital transformation

Source: compiled by the author based on Mishchenko (2024) and Mamchur et al. (2025).

Priority directions for agricultural digital development include digital solutions for production information management; platform-based information tools for integrated agricultural production management; multifunctional information flow management systems; upgraded and expanded information infrastructure; and optimised information exchange between agricultural enterprises and their counterparties.

A fundamental prerequisite for initiating agricultural digital transformation is therefore the development of modern information infrastructure capable of integrating agricultural producers into a shared information

environment, providing access to relevant information resources, and enabling widespread adoption of proven and promising digital technologies. Together, these factors substantiate the integrated use of organisational, economic, technological, and institutional methods and tools for agricultural digital transformation.

3.4. Comparative analysis of the effectiveness of EU and Ukrainian digital strategies

The study compares the EU's and Ukraine's strategic digital development documents to assess the effectiveness of digitalisation methods and tools in agriculture. The analysis covers key European and national programmes aimed at digital skills, infrastructure, innovation, e-government, and the digital economy more broadly.

The comparative findings indicate substantial alignment between the EU's and Ukraine's strategic objectives, creating favourable conditions for digital policy integration and the adoption of modern agricultural technologies (*Table 5*).

Table 5

Comparative analysis of EU and Ukrainian digital strategies

Document / programme	Objectives and priorities	Key areas	Integration potential
Digital Decade Policy Programme 2030	Achieve full EU digital transformation by 2030	Digital skills; infrastructure; business digitalisation; public services	Establish shared objectives and mechanisms for cooperation with Ukraine
Digital Compass	Define the principal benchmarks for digital development	Skills; infrastructure; business; public services	Align strategies and exchange best practices
eGovernment Action Plan	Modernise public services	Single digital portal; register nteroperability; once-only principle	Improve public service transparency and efficiency
Horizon Europe	Support research and innovation	Digital technologies; innovation; research and development	Enable Ukrainian researchers and enterprises to participate in joint projects
Concept for the Development of Ukraine's Digital Economy	Create conditions for digital economy development	Infrastructure; innovation; digital skills	Harmonise with European standards
Diia. Digital State	Ensure access to electronic services	Mobile application; electronic documents; online services	Integrate with European digital platforms
Digitalisation under the National Recovery Plan	Restore and modernise digital infrastructure	Broadband internet; startups; digital skills	Promote economic growth and social integration

Source: systematised by the author based on the Ministry of Digital Transformation of Ukraine (n. d.) and European Commission (n. d.).

When you look at the comparison, it is clear that European programs focus on a broad, systemic approach to digital development. They don't just look at one thing; they cover everything from human capital and infrastructure to innovation and governance. In the agricultural sector, this creates the right environment for things like precision farming, digital production management, satellite monitoring, and big data analytics to actually take root.

Ukraine is taking a similar path by rolling out digital services, electronic document management, and online access to public services, all while supporting innovative startups. The Diia platform and various electronic registers have been huge for agricultural businesses, helping to simplify administrative tasks, cut down on transaction costs, and make regulatory processes much more transparent.

On top of that, Ukraine's involvement in international research programs is a big factor in making digitalization more effective. By joining joint Horizon Europe projects, the country can facilitate technology transfers, spread innovative solutions, and build a modern scientific and technological base for agricultural production.

That said, the research also shows that how well digital tools are actually adopted in Ukraine depends a lot on a few key things: rural telecommunications infrastructure, access to funding, and how digitally literate agricultural workers are. Also, while the EU has a well-established system for monitoring and evaluating digital transformation, Ukraine's own mechanisms are still very much in the development stage.

Ultimately, the comparison shows that EU and Ukrainian digital strategies are built on the same core values and institutions, focusing on innovation, digital skills, and modern infrastructure. This shared foundation makes it much easier for Ukraine's agricultural sector to integrate into the European digital space.

By using these shared approaches to digitalization, Ukraine can see higher productivity, more efficient resource use, the growth of smart farming, and better competitiveness for its enterprises. In the long run, this will help speed up agricultural recovery after the war and lead to deeper integration with Europe.

Conclusions

The study examines digital transformation in Ukraine's agricultural sector in the context of sustainable development and European integration. The findings support the research hypothesis that digitalisation effectiveness depends not only on adopting individual technologies but also on coordinating technological, economic, organisational, and institutional measures.

The combined use of precision farming, artificial intelligence, IoT, GIS, and digital management platforms can increase productivity by 10–25%, reduce costs, and improve resource efficiency. However, small and medium-sized farms face considerable barriers. Their technology adoption costs per hectare may be 1.5–2 times higher than those of large enterprises, while complex organisational structures can increase integration costs by 20–40%.

The comparison with EU countries shows that European digitalisation relies on developed infrastructure, financial support, and cooperation between businesses, research institutions, and government. In Ukraine, digital development remains uneven, with large enterprises having better access to modern technologies.

The research hypothesis is supported by the finding that isolated digital solutions provide limited benefits, while coordinated implementation across production, logistics, and management offers greater potential for lasting improvements. Ukraine therefore needs better rural digital infrastructure, accessible financing, workforce training, and common digital maturity indicators.

Further research should focus on measuring digital transformation effectiveness and its impact on agricultural productivity and sustainable rural development.

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AI TOKENS IN THE CRYPTO ECOSYSTEM

The development of artificial intelligence contributes to its integration into the crypto ecosystem. This creates opportunities for improving automation projects in various fields using artificial intelligence algorithms and models based on their decentralization. The study hypothesized that artificial intelligence tokens are a significant component of the crypto ecosystem, which contributes, on the one hand, to expanding the circle of its participants and areas of coverage, and on the other hand, to transforming the spheres of human activity where they are used. To test the hypothesis, the stages of AI token evolution and factors influencing the development of AI tokens were systematized, the elements of the crypto ecosystem were clarified, the possibilities for using AI tokens in various fields were systematized, threats and opportunities for the development of AI tokens were identified, the prospects for the development of AI tokens, and the concept of AI tokens was clarified. To test hypothesis the following methods were used: historical, systemic, graphic, swot-analiz. Statistical data from CoinMarketCap, Statista and Kraken were used. Functional, design, and technological approaches to understanding artificial intelligence tokens have been clarified. The

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ТОКЕНИ ШТУЧНОГО ІНТЕЛЕКТУ В КРИПТОЕКОСИСТЕМІ

Розвиток штучного інтелекту сприяє його інтеграції в криптоекосистему. Це створює можливості для вдосконалення проєктів автоматизації різноманітних сфер через алгоритми та моделі штучного інтелекту на основі їх децентралізації. Висунуто гіпотезу, що токени штучного інтелекту (ТШІ) є вагомою складовою криптоекосистеми, що сприяє, з одного боку, розширенню кола її учасників та сфер охоплення, а з іншого – трансформації самих сфер діяльності людини, де вони використовуються. Для її перевірки здійснено систематизацію етапів еволюції ТШІ, чинників впливу на їхній розвиток, уточнено елементи криптоекосистеми, систематизовано можливості використання ТШІ у різних сферах, виявлено перспективи, загрози та можливості розвитку, уточнено визначення токенів ШІ. Для перевірки гіпотези використано історичний та графічний методи, системний підхід, свот-аналіз. Інформаційною базою стали статистичні дані CoinMarketCap, Statista та Kraken. Ідентифіковано такі етапи еволюції ШІ: зародження, вдосконалення та бум. Чинники

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following stages of the evolution of artificial intelligence tokens have been identified: emergence, improvement, and boom. Technological, economic, legal, and energy factors influencing the development of artificial intelligence tokens have been identified. The possibilities of using artificial intelligence tokens in various areas were identified.

The strengths and weaknesses of artificial intelligence tokens, threats and opportunities for their development have been identified. The educational, communication, operational, management, and stimulating functions of artificial intelligence tokens were first identified in the scientific literature. The scientific novelty is formulated definition of artificial intelligence tokens as an element of the crypto ecosystem that ensures the functioning of decentralized artificial intelligence platforms and provides users with the ability to automate their operational activities, facilitate transactions, and stimulate and manage the development of artificial intelligence.

Keywords: artificial intelligence tokens, cryptoecosystem, blockchain, autonomous finance.

впливу на розвиток ТШІ згруповано за технологічними, економічними, юридичними та енергетичними ознаками, а також визначено можливості застосування токенів штучного інтелекту в різних сферах.

У ході дослідження обґрунтовано навчальну, комунікаційну, операційну, управлінську, стимулюючу функції ТШІ. Наукова новизна полягає у розробці авторського визначення токенів штучного інтелекту як елемента криптоекосистеми, що забезпечує функціонування децентралізованих платформ штучного інтелекту та надає користувачам можливості автоматизації їх операційної діяльності, полегшення транзакцій, стимулювання та управління розвитком штучного інтелекту.

Ключові слова: токени штучного інтелекту, агенти штучного інтелекту, криптоекосистема, блокчейн, автономні фінанси.

Jel Classification: G19, O16.

Introduction

Artificial intelligence (AI), which is becoming the most important technology of the 21st century, is characterized by significant centralization and concentration, which may lead to problems of bias and unjustified censorship (Robertson, 2024, February 22). The convergence of AI and blockchain technology in the virtual asset market contributes to reducing bias and the concentration of ownership rights within the AI system, which is important given its widespread application in virtually all areas of human activity. This has led to the emergence of a type of virtual asset known as AI-based tokens. Their functioning creates the basis for increasing global network participants' access to artificial intelligence by reducing the fees for using its services and expanding the range of participants who can determine the directions of AI project development. While traditional cryptocurrencies generally serve as a means of payment and a store of value, artificial intelligence tokens (AITs) are intended for data analysis, trade automation, market forecasting based on continuous learning, and improving the efficiency of trading and service-provision environments. The integration of AI and virtual assets creates opportunities for developing projects that automate various fields based on AI algorithms and models.

Many academic studies have addressed the application of AI in the financial sector. Dziura et al. (2025) examined ways of adapting AI in the financial sector from the perspective of Industry 4.0 development. Akour et al. (2024) identified opportunities for using AI in financial decision-

making. However, this concerns only the investment sector. Wang et al. (2024) examined the possibilities of applying AI to monitor financial risks in asset management. This study focuses on the activities of enterprises. Azeema et al. (2023) emphasize that AI has a dual impact on financial markets, creating both new opportunities and certain challenges for market participants. This applies to the financial market as a whole; however, the virtual asset market remained outside the authors' focus.

Specific aspects of AIT functioning have been addressed in academic studies, most of which focus on technical aspects. Research into the economic nature of artificial intelligence tokens only began to emerge in 2024–2025. Most of these studies have been conducted by consulting and research centers, which can be explained by the recent emergence of AITs on the market. Various terms are used in this context. For example, AITs are also referred to as AI crypto tokens (Ko & Chen, 2025), AI cryptocurrencies (Ganapathy et al., 2020), and AI coins (Kraken, 2024, November 21). However, in our view, the term "artificial intelligence tokens" (AI tokens, AITs) is the most appropriate and most widely used.

The results of the analysis of scholars' and practitioners' approaches made it possible to systematize the understanding of the nature of AITs within the functional, technological, and project-based dimensions. From the perspective of the functional approach (Anglen, 2024), AI tokens are digital assets that use artificial intelligence technologies to improve their functionality and utility. However, the functions of AITs are not specified.

Representatives of the technological approach, Ko and Chen (2025), emphasize that AITs belong to the category of cryptocurrencies that integrate artificial intelligence technologies into their operations. Mafrur (2025) considers AITs to be cryptographic assets designed to support decentralized artificial intelligence platforms and services. However, the ways in which AI tokens support these platforms and services remain unspecified. According to the project-based approach, Coingecko (2026) defines AI tokens as cryptocurrency assets that support artificial intelligence-related projects, such as AI-based portfolio management, image generation, and pathfinding. However, this approach somewhat narrows the range of projects that can actually use AI tokens.

In the academic literature, researchers focus on the relationship between AITs and specific components of the financial market. For example, Yousaf et al. (2024b) identified a relationship between AI tokens and traditional asset classes, while Jareño and Yousaf (2023) examined their relationship with other AI-based assets. Yousaf et al. (2024a) investigated volatility spillovers between AITs, AI stocks, and fossil fuel markets. To date, research on AITs has largely focused on their role in investment portfolios. In particular, Ko and Chen (2025) point to a high probability of substantial losses during periods of market instability, indicating the limited diversification potential of AI assets within non-diversified portfolios.

Artificial intelligence tokens should be distinguished from AI tokenization, which involves converting large volumes of information (textual, visual, or audio data) into specific units (tokens) organized into structured units, thereby enabling artificial intelligence to process them and generate certain information. Despite significant progress in AIT research, gaps remain in the systematization of factors influencing their development, the identification of their functions, the systematization of opportunities for their use in various fields, and the identification of their development prospects within the crypto ecosystem. Given the diversity of existing approaches, the concept of AI tokens itself requires further clarification.

The purpose of the article is to determine the role of artificial intelligence tokens as a component of the crypto ecosystem, identify their potential applications, and substantiate their development prospects.

In the course of the study, the hypothesis was put forward that artificial intelligence tokens constitute a significant component of the crypto ecosystem, contributing, on the one hand, to expanding the range of its participants and areas of coverage and, on the other hand, to transforming the very areas of human activity in which they are used. To test this hypothesis, the stages of AIT evolution and the factors influencing their emergence and development were systematized; the elements of the crypto ecosystem were clarified; the possibilities for using AI tokens in various fields were systematized; and the threats and opportunities associated with the development of AITs as a component of the crypto ecosystem were identified. Based on the findings of the study, the prospects for the development of AI tokens as a component of the crypto ecosystem were outlined, and their definition was refined.

To achieve this objective, a set of scientific methods was employed. In particular, the historical method was used to identify the stages of AI token evolution. The analysis of statistical data from CoinMarketCap, Statista, and Kraken helped identify trends in global investment in artificial intelligence and the market capitalization of AITs. The systems approach provided the basis for identifying the factors influencing the development of AI tokens. The assessment of the strengths and weaknesses of AITs was based on an analysis of their characteristics, while the analysis of threats and opportunities was based on the specific features of AI tokens' functioning within the crypto ecosystem. Subsequently, the results of the SWOT analysis served as the basis for forecasting the prospects for the further development of artificial intelligence tokens.

The main body of the article consists of three sections: the first is devoted to describing the stages of AIT evolution; the second focuses on analyzing the investment component of their development; and the third addresses the position of AI tokens within the crypto ecosystem and identifies their development prospects.

1. Evolution of artificial intelligence tokens

Mishchenko et al. (2024) propose viewing artificial intelligence as a comprehensive systemic set of technical and technological solutions developed on the basis of relevant logical algorithms, formed by identifying patterns in the functioning of individual processes or phenomena. These solutions make it possible to imitate the human ability to think logically and, on this basis, produce certain generalizations, decisions, or recommendations. Artificial intelligence tokens have a relatively short history. However, due to their potential to transform various industries, AITs are becoming increasingly important in the financial technology ecosystem. They are associated with the functioning of decentralized platforms that provide certain benefits to users.

The evolution of AITs has gone through several stages. The *first stage* – their emergence – lasted approximately from 2017 to early 2021. The emergence of AI tokens in the virtual asset market is generally associated with 2017, when interest developed in the possibilities of integrating blockchain technology with artificial intelligence. However, the first projects that attempted to address issues related to data exchange, machine learning algorithms, and the allocation of computing resources did not develop further due to low levels of trust and the insufficient technological efficiency available to users at that time. The cryptocurrency boom of 2017–2019 laid the foundation for the formation of a decentralized artificial intelligence market, within which opportunities for exchanging and trading AI models were created. During this period, attention focused on identifying ways to reduce computing resource costs and maintain data confidentiality.

The *second stage* in the evolution of AI tokens (2020–2023) was associated with their improvement. On the one hand, new technologies began to be applied, including iris scanning (*Worldcoin*); on the other hand, AI technologies began to be used in new fields, particularly to identify consumer behavior patterns and conduct analyses in the field of cryptocurrency transactions (Arkham). This enabled AITs to become an integral component of the crypto ecosystem.

The *third stage* in the evolution of AI tokens began in 2024 and is characterized by the growing popularity of artificial intelligence agents, which has taken place against the backdrop of the AIT boom.

The purpose of creating and subsequently using artificial intelligence-based tokens is to:

- automate processes in various fields;
- improve the security of transactions;
- enhance the personalization of services provided to users.

The characteristic features of AITs are that they:

- are digital assets;
- provide for community ownership rather than company ownership (Izockey, 2025, April 14);

- are utility tokens;
- have a limited supply set by platforms that seek to control inflationary processes and ensure fair use;
- require payment for tasks performed by artificial intelligence;
- are intended not for storage but for carrying out specific operations;
- are generally compatible with various platforms, as they typically operate on major blockchains, including Ethereum and Cosmos.

Artificial intelligence tokens perform the following functions:

- educational, which provides users with access to such tools as machine learning models, predictive analytics, and automated decision-making systems;
- communication, which enables interaction between artificial intelligence users and AI platforms;
- operational, which enables language processing and image recognition, as well as the buying, selling, and exchange of data used for AI development;
- governance, which enables token holders to participate in decision-making regarding the operation of an AI platform;
- incentive, which provides participants with rewards.

In our view, the primary function of AI tokens is the operational function, which facilitates users' access to artificial intelligence capabilities and enables them to carry out transactions within decentralized platforms.

2. Development of artificial intelligence tokens

The advantages of using AI in various fields have stimulated the interest of potential investors. Global private investment in AI increased over the period 2015–2024 (*Figure 1*). At the same time, the growing potential of AI tokens to decentralize the AI market creates the conditions for the growth of this segment.

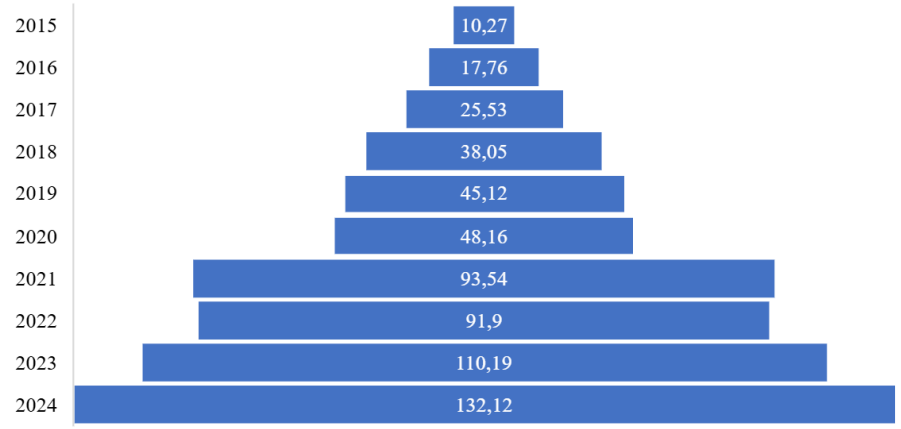


Figure 1. Global Private Investment in Artificial Intelligence, 2015–2024

Source: compiled by the authors based on (Thormundsson 2024, December 11).

As shown in *Figure 2*, the artificial intelligence and big data token sector has experienced a boom in the global virtual asset market since 2024. Subsequently, the market capitalization of AI and big data tokens declined somewhat; however, compared with previous periods, it remains significantly higher.

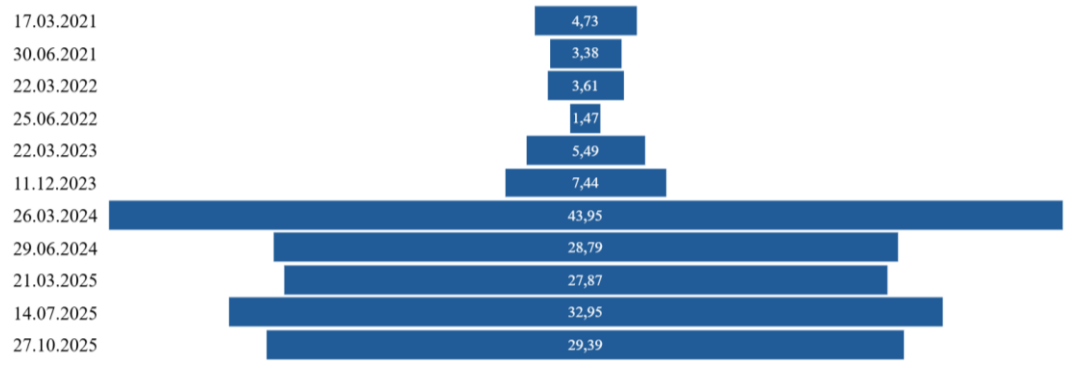


Figure 2. Market capitalization of AI and Big Data tokens from 17 March 2021 to 27 October 2025, USD billion

Source: compiled by the authors based on (CoinMarketCap 2026).

In 2024, global corporate investment in artificial intelligence amounted to USD 252.3 billion, while global private investment reached USD 33.94 billion, following a tenfold increase over the previous decade (Kariuki, 2025). At the same time, the results of a survey of cryptocurrency holders in the United States indicate that 48% of respondents are optimistic about the long-term potential of AI tokens, while 24% of respondents stated that they were already investing in AI tokens and 27% expressed a desire to invest in them in the future (Kraken, 2025, April 7).

Currently, 109 artificial intelligence tokens are available on the market (Forbes, 2026). *Table 1* provides an overview of the top 5 tokens by market capitalization.

Table 1

Overview of the top 5 artificial intelligence tokens by market capitalization (as of 5 January 2026)

Name	Year founded	Blockchain	AI token categories	Application areas	Market capitalization, USD billion	Price, USD
Chainlink	2017	Ethereum	AI agents	Finance, gaming. This token is used by Swift, JP Morgan, Mastercard, Euroclear, Fidelity International, UBS, ANZ, Aave, GMX, and Lido	9.6	13.5

End of Table 1

Name	Year founded	Blockchain	AI token categories	Application areas	Market capitalization, USD billion	Price, USD
Bittensor	2019	Subtensor	Generative AI	Cryptocurrency trading, autonomous driving, photography. Developers are rewarded for their contributions to a shared AI model	2.8	265
Near Protocol	2017	Ethereum	AI agents	Payment of transaction fees and provision of collateral for data storage on the blockchain	2.2	1.75
Internet Computer	2016	Ethereum	AI agents	Enables AI to create applications, websites, and enterprise systems for mass-market users through instructions provided via chat, offering a serverless environment. It allows smart contracts to interact directly with real-world data and services, while ensuring censorship resistance and cryptographic security. For example, applications such as OpenChat (a decentralized social platform) operate entirely on ICP without centralized hosting	1.7	3.24
Render	2009	Ethereum, from 2.11.2023 – Solana	Generative AI	Art, gaming, fashion, and the film industry through the use of 3D images, special effects, animation, and graphics software by artists, engineers, designers, developers, and film directors	1.0	2.1

Source: compiled by the authors based on (Kraken, 2024, November 21; Izockey, 2025, April 14; Bank for International Settlements, 2023, July 11).

The factors influencing the development of AI tokens can be divided into technological, economic, legal, and energy-related factors. *Technological factors* include:

- the availability of modern graphics processing units (GPUs) and high-speed memory, which makes it possible to reduce information processing time;
- increases in the processing power of next-generation GPUs;
- the transition from GPUs to specialized application-specific integrated circuits (ASICs) for training;
- the availability of specialized infrastructure.

Among the *economic factors*, the following should be highlighted:

- price volatility of AI tokens;
- reductions in computing costs;
- growing user demand for AI systems;
- intensifying competition in the AI market.

Energy-related factors influencing the development of AI tokens include the increase in electricity consumption required to operate artificial intelligence systems. In 2024, US data centers consumed approximately 200 terawatt-hours of electricity, of which AI servers accounted for 53–76 terawatt-hours, an amount sufficient to supply electricity to more than 7.2 million American households for a year. According to *Poshenergy* (2025, June 11), AI-related electricity consumption is expected to more than double by 2030. This will undoubtedly also affect the operation of AI tokens.

Legal factors involve the impact of the regulatory environment on the functioning of the AI token sector. Recently, national and global regulators have shown increasing support for the development of the AI token sector, which has had a positive effect on this segment of the virtual asset market.

3. Artificial intelligence tokens: their place in the crypto ecosystem and development prospects

The scientific literature does not provide a definition of the crypto ecosystem or specify the composition of its elements. Only the Bank for International Settlements (Bank for International Settlements, 2023) identifies the following elements of the crypto ecosystem: cryptoassets, stablecoins, smart contracts, and decentralized finance. Although this approach was proposed recently, it has already become somewhat outdated, as it reflects only certain elements of the crypto ecosystem, namely, types of virtual assets (cryptoassets and stablecoins), a financial technology instrument (smart contracts), and a component of the financial system (decentralized finance). However, the range of virtual assets and instruments within the crypto ecosystem is considerably broader.

At the same time, participants are an important component of any ecosystem, including the crypto ecosystem. The emergence of tokens has contributed to the entry of new participants into the crypto ecosystem, including entities operating in logistics, the fashion industry, and the energy sector, as well as gambling businesses and artists. Furthermore, the scope of the crypto ecosystem is currently expanding through the introduction of new

types of virtual assets, including AI tokens, and the enhancement of their functionality. In view of this, when defining the elements of the crypto ecosystem, we propose expanding the range of virtual assets and their areas of application, particularly AI tokens, and incorporating the participants of the crypto ecosystem as an additional element. To gain a deeper understanding of the place of AI tokens within the crypto ecosystem, the element "AI token application opportunities" is introduced. *Figure 3* illustrates the place of AI tokens within the crypto ecosystem.

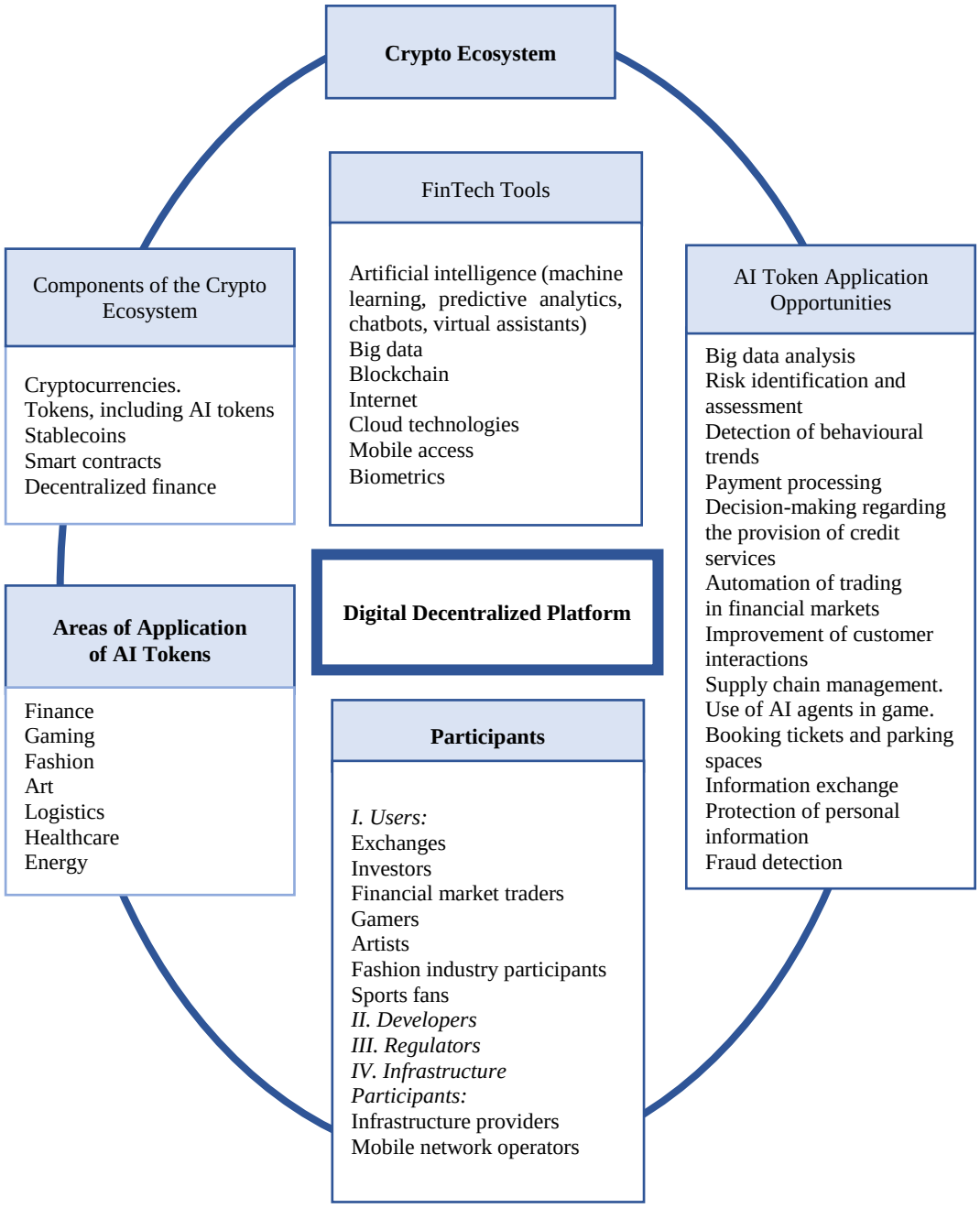


Figure 3. Artificial intelligence tokens in the crypto ecosystem

Source: compiled by the authors based on the Bank for International Settlements (2023, July 11) and their own research.

As a component of cryptoassets, AI tokens are used in their operations alongside various financial technology tools, the main ones being artificial intelligence and blockchain. However, the current development of AI tokens also involves the use of biometrics (iris recognition – the Worldcoin token); mobile access (the *ASI* token) (Hryniv, 2024, February 21); and cloud technologies (the FET and ASI tokens on the *Fetch.ai* platform). Participants in the AI token ecosystem include users, developers, regulators, and infrastructure entities, which interact through a digital decentralized platform.

Artificial intelligence tokens are used in such areas as finance, gaming, logistics, healthcare, and digital art. Their application in these areas involves:

- operational activities;
- facilitating transactions;
- incentivizing participants;
- ownership-related activities.

The potential applications of AI tokens are presented in *Table 2*.

Table 2

Applications of artificial intelligence tokens

Operational Activities	Facilitating Transactions	Incentivizing Participants	Ownership-Related Activities
Model training Data processing Predictive analytics Portfolio management Image generation Data exchange Decision-making	Conducting transactions on the platform Purchasing or renting AI models Accessing AI-based platform services	Offering rewards for: • Contributing data to the network; • Providing computing power; • Developing AI software	Investing in AI tokens Granting governance rights over the platform

Source: compiled by the authors based on (Kraken, 2024, November 21; CoinGecko, 2026).

The operational applications of AI tokens and the ways in which they incentivize participants may vary slightly depending on the area in which AI tokens are used within the crypto ecosystem.

In the *financial* sector, artificial intelligence-based tokens make it possible to:

- personalize the provision of financial services to clients based on users' histories and reputations, thereby increasing user satisfaction and encouraging long-term participation in decentralized financial systems;
- facilitate financial planning through the early detection of market instability and liquidity problems using predictive analytics based on a wide

range of data and multiple scenarios, enabling appropriate decisions to be made before losses increase;

- interact with users through chatbots and robo-advisors;
- establish decentralized autonomous investment organizations (DAOs) that combine the automated provision of recommendations to token holders based on outcome modelling with community voting on ideas proposed by any participant, thereby democratizing the investment process;
- copy the successful investment strategies of other traders;
- adjust interest rates and reduce the risk of default based on dynamic assessments of borrowers' creditworthiness, market volatility, and collateral value;
- mine cryptocurrency;
- detect suspicious activities, fraudulent transactions, and money laundering by aligning AI projects with regulatory requirements and investors' expectations.

Thus, financial service providers can use AI tokens to strengthen their competitive position in the market by enhancing customer orientation, operational efficiency, and the soundness of decision-making. The emergence and development of AI tokens have led to the formation of a segment of the crypto ecosystem known as *DeFAI* (autonomous finance, AgentFi), which involves integrating AI agents into decentralized finance and automating big data analysis and transaction execution. This contributes to a certain degree of democratization of the financial sector.

AI tokens have created opportunities for the development of the gaming market. Players are offered personalized experiences based on individual interactions with an agent, which increases their engagement. Tokens provide ownership rights to AI agents, allowing them to be sold, exchanged, or rented. As a result, incentives to invest in and train AI agents increase. Tokens also enable the same AI agents to be used across different games and platforms. This creates the foundations for a gaming ecosystem that offers participants broader economic opportunities and an improved gaming experience. AI tokens are becoming an attractive investment instrument, strengthening the links between the gaming industry and the financial sector within the crypto ecosystem.

AI tokens can serve as a tool for artists to create digital works while ensuring ownership rights and the authenticity of the digital artwork for buyers. An example of the application of AI tokens in digital art is the Image Generation AI (IMGNAI) token, which users of Discord and Telegram employ through the Nai bot to generate images using machine learning, including anime and *3D* images.

In the *energy* sector, AI tokens enable the automation of data collection and analysis concerning grid operations, as well as real-time electricity payments, thereby improving grid management efficiency. At the same time, it is hoped that this tool will help overcome inequities in access

to energy among certain categories of consumers and promote the development of renewable energy (*RWA.io,* 2025, December 11). In the operation of electric vehicles, AI tokens automate processes related to trip payments, route tracking, and vehicle fault detection.

In *healthcare*, AI tokens are used to improve diagnostics, treatment processes, data exchange, drug development, and billing. *Table 3* presents the strengths and weaknesses of AI tokens, as well as the opportunities and threats associated with their development.

Table 3

SWOT Analysis of artificial intelligence cryptocurrencies

Strengths	Weaknesses
Real-time fraud detection	Market volatility
Increased process transparency	Low liquidity
Reduced operating costs and transaction times	Ambiguity of regulatory requirements
Reduced transaction processing time	Technical difficulties in adapting AI models to the limitations of blockchain platforms
Reduced electricity consumption	Costs associated with performing tasks despite the availability of free alternatives
Increased computing speed and data storage capabilities through the decentralization of internet infrastructure	Lower computing power and efficiency compared with centralized systems
Threats	Opportunities
Loss of confidentiality of data used by AI in tokens	Making optimal decisions based on historical data in real time
Fraudulent activities targeting inexperienced users who do not sufficiently understand how AI-based decentralized platforms operate	Expanding the role of AI tokens in facilitating cross-border transactions and interactions
Changes in regulatory requirements	Forecasting price trends in markets
Disproportionately high levels of speculation compared with actual platform usage	Helping stabilize prices under conditions of market volatility
Difficulties in complying with financial legislation due to the uncertain legal nature of tokens	Integration with traditional financial systems
	Ensuring fair access to credit and investment instruments

Source: compiled by the authors based on (Mafrur, 2025; IzockeyI, 2025) and their own research.

Thus, we will attempt to forecast the future development of AI tokens as a component of the crypto ecosystem. *First*, AI tokens are expected to operate in conjunction with other financial technology tools alongside AI and blockchain, particularly big data, biometrics, and cloud technologies, which will promote synergies in their use. *Second*, regulatory restrictions on AI tokens are expected to become stricter at both global and national levels, with severe sanctions imposed on those who violate regulatory requirements. At present, regulatory capabilities lag behind the pace at which AI tokens are being introduced into various areas of human activity. As a result, low-

quality tokens may circulate in the market, while consumer rights remain inadequately protected. *Third*, the use of AI tokens is expected to expand further across the financial sector, energy, gaming, logistics, and healthcare. Growing demand for AI tokens and improvements in their efficiency will, on the one hand, drive an increase in global investment in AI tokens and, on the other, may trigger the Jevons paradox, potentially leading to increased energy intensity in this segment of the crypto ecosystem.

Conclusions

The research findings confirmed the hypothesis that the emergence and development of artificial intelligence tokens contribute to expanding the range of participants and areas of the crypto ecosystem, leading to the formation of new properties. At the same time, increased technological sophistication and customer orientation are driving transformations in the financial sector, logistics, the gaming industry, healthcare, the energy sector, art, fashion, and sports.

The identification of functional, technological, and project-based approaches to understanding AI tokens, as well as the determination of their place within the crypto ecosystem, made it possible to refine their definition as elements of the crypto ecosystem that ensure the functioning of decentralized artificial intelligence platforms and provide users across various sectors with opportunities to automate their operational activities, facilitate transactions, incentivize participation, and manage the development of artificial intelligence.

The research made it possible to systematize the following functions of artificial intelligence tokens: operational, communication, training, and governance. As digital assets, AI tokens perform these functions by enabling the automation of certain processes, enhancing the security of transactions, increasing service personalization, providing opportunities to participate in improving the performance of AI platforms, and allowing participants to receive rewards.

For the first time, this article systematizes the factors influencing the emergence and development of artificial intelligence tokens into the following groups: technological, economic, legal, and energy-related. This provided the basis for identifying the following stages in the development of AI tokens on the global market: emergence, refinement, and boom. It should be noted that technological factors are dominant, as the use of additional *FinTech* tools generates synergies and expands the operational capabilities of AI tokens, whose functioning is underpinned by artificial intelligence and blockchain.

The research demonstrated that there are two development trajectories for artificial intelligence tokens: product-based trajectories, which involve expanding their operational capabilities, and sectoral trajectories, which involve broadening their areas of application.

Future research into the functioning of AI tokens will focus on scenario analysis of their development, particularly in financial markets.

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CRYPTOCURRENCY MARKET AS AN ASYMMETRIC DUOPOLY: COMPLEMENTARITY AND COMPETITION BETWEEN BITCOIN AND ETHEREUM

Despite an extensive body of research on cryptocurrency price forecasting and volatility assessment, the nature of market interaction between Bitcoin and Ethereum in terms of market organization theory remains largely unexplored. The article is devoted to verifying the hypothesis of an asymmetric duopoly structure between Bitcoin and Ethereum. Three hypotheses are proposed: Bitcoin price leadership (H1), Cournot quantity equilibrium (H2), and partial asset complementarity (H3). The methodological framework comprises correlation analysis of logarithmic price levels and returns, market share analysis using both price-based and volume-based metrics, and regression estimation of three Bertrand models and a Cournot model with lagged BTC market share. The empirical base consists of daily Yahoo Finance data for 2017–2026, aggregated to monthly averages. The results confirm the price leadership hypothesis (H1); the asymmetry of 0.402 quantitatively confirms Bitcoin's dominance. The Cournot hypothesis (H2) in its classical formulation is rejected, and a capital rotation mechanism from BTC to ETH with a one-month lag is established. The complementarity hypothesis (H3) is confirmed by both analytical blocks. It is concluded that the cryptocurrency market operates as an asymmetric duopoly in which price competition follows the Bertrand model with Bitcoin as the leader, while complementary demand dominates at the level of market shares.

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КРИПТОРИНОК ЯК АСИМЕТРИЧНА ДУОПОЛІЯ: КОМПЛЕМЕНТАРНІСТЬ І КОНКУРЕНЦІЯ МІЖ *BITCOIN* І *ETHEREUM*

Попри широкий масив досліджень із прогнозування цін й оцінки волатильності криптоактивів, питання характеру ринкової взаємодії між Bitcoin і Ethereum в термінах теорії ринкової організації залишається практично недослідженим. Проаналізовано верифікацію гіпотези про існування асиметричної дуопольної структури між Bitcoin і Ethereum. Висунуто три гіпотези: цінового лідерства Bitcoin (H1), кількісної рівноваги Курно (H2) та часткової комплементарності активів (H3). Методологічну основу дослідження становлять кореляційний аналіз логарифмічних рядів цін і доходностей, аналіз ринкових часток за ціновою та торговою метриками, а також регресійне оцінювання трьох моделей Бертрана і моделі Курно з лаговою часткою BTC. Емпіричною базою стали щоденні дані Yahoo Finance за 2017–2026 рр., агреговані до місячних середніх. Результати підтверджують гіпотезу цінового лідерства (H1), асиметрія у 0.402 кількісно підтверджує домінування Bitcoin. Гіпотезу Курно (H2) у класичному формулюванні відхилено і констатовано механізм ротації капіталу від BTC до ETH з місячним лагом. Гіпотеза комплементарності (H3) підтверджена за обома аналітичними блоками. Зроблено висновок, що крипторинок функціонує як асиметрична дуополія, де цінова конкуренція реалізується за моделлю Бертрана з лідером Bitcoin, а на рівні ринкових часток домінує комплементарний попит.

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Keywords: Bitcoin, Ethereum, duopoly, Bertrand model, Cournot model, price leadership, market shares, complementarity, cryptocurrency market.

Ключові слова: *Bitcoin*, *Ethereum*, дуополія, модель Бертрана, модель Курно, цінове лідерство, ринкові частки, комплементарність, криптовалютний ринок.

JEL Classification: G10, L13, C58.

Introduction

The cryptocurrency market is one of the most dynamic and analytically under-researched segments of the modern digital economy. A substantial share of global crypto-market capitalization is consistently concentrated in two assets – Bitcoin (BTC) and Ethereum (ETH) – which form a duopolistic structure atypical of traditional financial markets. At the same time, the dichotomy between competition and complementarity of Bitcoin and Ethereum cannot be described by the standard duopoly model in its classical sense, for three reasons.

First, although these digital assets compete for investment demand, they serve qualitatively different investment functions: store of value (Bitcoin is primarily positioned as a digital savings vehicle and a hedging instrument) and programmable infrastructure (Ethereum is the base infrastructure for decentralized finance, smart contracts, and tokenomics), which rules out pure substitution.

Second, the supply of both assets is determined algorithmically rather than by the strategic decisions of players, which eliminates the key mechanism of Cournot quantity competition, in which each player deliberately chooses its output in response to a competitor's decision. In Bitcoin and Ethereum, supply is algorithmically deterministic: Bitcoin issuance is set by the protocol (a halving every four years, with a fixed cap), while Ethereum issuance is governed by the Proof-of-Stake mechanism and by burning under EIP-1559. Neither player makes strategic decisions about quantity; the protocols do so automatically. The relevance of the study is heightened by current structural shifts in the market: Ethereum's transition to Proof-of-Stake in 2022 and the active growth of the Layer-2 solutions market since 2021, which increases complementarity between the assets. On the other hand, the approval of Bitcoin ETFs in 2024 is a structural break that reinforces the asymmetry of the duopoly, since Bitcoin has acquired the characteristics of a self-standing institutional asset class, consistent with the concept of a "digital value reserve" and deepening its functional differentiation from Ethereum (Li et al., 2026). These developments alter the parameters of the duopoly and make a quantitative assessment of the market characteristics of both digital assets timely and necessary.

Third, empirical data (Yahoo Finance, n. d.) show a synchronous rather than competitive growth in market shares, which contradicts the logic of mutual displacement.

Therefore, the analysis of BTC and ETH requires an adapted version of the duopoly model in which functional differentiation replaces product

differentiation. Thus, the dichotomy between competition and complementarity of Bitcoin and Ethereum calls for the development and application of adapted theoretical and methodological provisions.

Turning to contemporary scholarly work, one can state that most of it focuses on price forecasting or on volatility assessment of individual assets, whereas the market structure and the nature of interaction among the leading crypto assets remain largely unexplored.

Thus, in the contemporary scientific literature, cryptocurrencies are treated as a multidimensional phenomenon that combines financial, technological, and institutional aspects. The Johansen cointegration tests in the study by Saka Ilgın (2024) show no cointegration between BTC/ETH and traditional asset classes. The Granger causality test revealed unidirectional causal relationships running from Bitcoin and Ethereum prices to the Dow Jones commodity index, especially after 2021–2022. Kraus and Rosokhatska (2022) emphasize the speculative nature of cryptocurrencies, while at the same time acknowledging their potential as an alternative asset with store-of-value properties.

Mazaraki and Volosovich (2022) focus on the institutional and technological aspects of mining, stressing its transformation under the influence of energy, regulatory, and geopolitical factors that determine the economic viability and sustainability of the crypto industry. Melnyk and Klym (2022) examine cryptocurrencies in the context of cybersecurity, pointing to their dual nature: both as a tool for enhancing transaction security and, at the same time, as a means of cybercrime, which creates new challenges for public policy. Meanwhile, Fomina and Semenova (2022) analyze problems in the accounting of crypto assets, emphasizing the absence of unified standards in the European Union and Ukraine, as well as the need to adapt accounting approaches to the specifics of digital assets.

In addition, contemporary studies are devoted to applying machine learning methods to the analysis of the cryptocurrency market. The sources and quality of input data for forecasting models are systematized by Sitailo (2024), who distinguishes three categories of analysis (technical, fundamental, and socio-economic) and describes practical methods of collecting data from crypto exchanges, blockchains, and social networks. Attention is also paid to hybrid artificial intelligence architectures and neural networks (Dobrolyubova et al., 2025; Kozenkova & Movsesyants, 2025) and to WGAN combinations for generating synthetic time series (Babych, 2025). Chyzhevska et al. (2025) apply an FNN model to medium-term Bitcoin price forecasting and show that integrating technical indicators (SMA, RSI, MACD) substantially improves forecast accuracy.

In parallel, a line of research on causal relationships between events in the crypto market is developing. Troyan (2024) studies the internal market dynamics over 2017–2024 using Granger causality tests and finds that platform tokens are the most influential category, while the market itself is characterized by rapid propagation of price impulses across assets.

Iyer and Popescu (2023) investigate the transmission of returns and volatility between crypto assets and global financial markets in 2014–2022 and confirm an asymmetric structure of price-signal transmission. However, the authors treat ETH and BTC symmetrically, without identifying a hierarchy between them.

Korkusuz (2025) concludes that Ethereum acts as the most influential driver of volatility, reflecting the asset's key role in DeFi and decentralized finance. At the same time, Joshi (2025) maintains that in the volatile regime, BTC consistently acts as the principal source of shocks, while ETH is a secondary transmitter and XMR is mainly a recipient. The Granger causality test reveals more stable and statistically significant causal relationships in the stable regime.

The line of comparative analysis of investment assets is represented by Hutsul (2025), who examines how investment priorities shift between gold and cryptocurrencies and finds that Bitcoin is gradually assuming the function of a "digital value reserve," while traditional assets retain the role of a portfolio stabilizer. Polyansky and Litvinenko (2025) evaluate the effectiveness of a countertrend trading strategy for BTC and ETH and show that BTC demonstrates considerably higher stability than ETH, which indirectly indicates a different nature of the market behavior of the two assets and confirms their functional differentiation.

The above works treat Bitcoin and Ethereum as separate assets or as elements of a diversified portfolio, but none of them examines these two assets as a structural pair of participants in a stable market duopoly with its own logic of price leadership and distribution of market shares. Yet precisely such a framing corresponds to reality: throughout 2017–2026, BTC and ETH together have consistently held dominant positions in the capitalization structure of digital assets, forming a distinct market configuration. Thus, the scientific problem lies in the absence of a theoretically grounded and empirically verified description of the structure of interaction between Bitcoin and Ethereum in terms of market organization. Filling this gap requires adapting microeconomic duopoly models to the specifics of the cryptocurrency market and testing the nature of competitive relations between the two leading digital assets.

The purpose of the article is to verify the hypothesis of an asymmetric duopoly structure between Bitcoin and Ethereum by empirically testing the implications of the Bertrand price competition and Cournot quantity competition models. In line with this purpose, the following hypotheses are formulated:

price leadership hypothesis H1 assumes that *Bitcoin* is the price leader in the duopoly and that *BTC* price changes are transmitted to *ETH* asymmetrically, which indicates a hierarchical structure of price leadership;

quantity equilibrium hypothesis H2 proceeds from the assumption that the market shares of Bitcoin and Ethereum form a stable Cournot equilibrium,

i.e., an increase in the market share of BTC is statistically significantly and inversely related to the change in the share of ETH in the next period;

complementarity hypothesis H3 assumes that common market factors dominate the substitution effect, which manifests itself in a positive correlation of returns and indicates partial complementarity of the assets in portfolio demand.

The data source comprises daily closing prices and trading volumes of Bitcoin (BTC–USD) and Ethereum (ETH–USD) for the period from January 1, 2017 to March 20, 2026 (Yahoo Finance, n.d.). For comparative analysis, prices are aggregated to monthly averages and rebased to a common base (index = 100 at the beginning of 2017). In addition, in order to correctly represent the multiplicative growth of digital asset prices and to mitigate the non-stationary distribution of the price time series, a logarithmic transformation was applied.

To distinguish short-term co-movement of prices from long-term cointegration, correlation analysis is applied in two directions: the correlation of log price levels and the correlation of first differences of logarithms (log returns).

The subsequent analysis of the market shares of digital assets is likewise conducted in two directions: price share and share in trading volumes. Comparing these indicators and analysing the difference between the shares makes it possible to identify discrepancies between price and trading dominance and to test the stability of the duopoly structure in recent years.

Given the specifics of crypto assets, where supply is determined algorithmically, and demand is shaped by reflexive expectations, marginal costs for the end investor are effectively absent. Under these conditions, an empirical test of the implications of the Bertrand and Cournot models for BTC and ETH makes it possible to assess whether the cryptocurrency market can be interpreted in terms of a classical duopoly or to delineate the limits of applicability of such models.

To test the implications of the Bertrand model, three regression models in logarithmic first differences are constructed:

levels model:

$$\ln(ETHt) = \alpha + \beta \cdot \ln(BTCt) + \varepsilon t, \quad (1)$$

elasticity of ETH with respect to BTC:

$$\Delta\ln(ETHt) = \alpha + \beta_1 \cdot \Delta\ln(BTCt) + \varepsilon t, \quad (2)$$

elasticity of BTC with respect to ETH:

$$\Delta\ln(BTCt) = \alpha + \beta_2 \cdot \Delta\ln(ETHt) + \varepsilon t. \quad (3)$$

The asymmetry of the coefficients β_1 and β_2 is the key test of price leadership.

To test the implications of the Cournot model, a regression of the change in the market share of *ETH* on the lagged value of the *BTC* share is constructed:

$$\Delta s_{ETH,t} = \alpha + \beta \cdot s_{BTC,t-1} + \varepsilon t. \quad (4)$$

A statistically significant value of the coefficient β can be interpreted as confirmation of Cournot equilibrium dynamics. The estimation is carried out using the feols function from the fixest package in the R software environment.

Thus, the empirical study is built as a sequence of interrelated analytical blocks that reflect the logic of testing the proposed hypotheses regarding the duopoly structure of the cryptocurrency market. The first section analyses the dynamics of the Bitcoin and Ethereum price series, including their transformation (logarithmization, aggregation) and an assessment of the co-movement of prices through correlation analysis in levels and returns, which allows short- and long-term relationships to be distinguished. The second section is devoted to analysing the market shares of BTC and ETH in both price and trading terms, which makes it possible to assess the structure of dominance and its stability over time. The third section examines price leadership within the Bertrand model by constructing regressions in logarithmic increments and comparing sensitivity coefficients, which reveals the asymmetry in the transmission of price impulses between the assets. The fourth section is devoted to testing the implications of the Cournot model by estimating the dynamic dependence between market shares, which allows the interaction of digital assets to be interpreted in terms of quantity competition. Taken together, these stages of the study form a coherent empirical framework that makes it possible not only to test hypotheses about the nature of the interaction between Bitcoin and Ethereum, but also to assess the applicability of classical models of oligopolistic competition to the cryptocurrency market.

1. Correlation analysis of logarithmic price series of Bitcoin and Ethereum

The correlation analysis of the logarithmic price series of Bitcoin and Ethereum revealed two distinct levels of interdependence.

The correlation of log levels made it possible to establish a long-term common trend of the two assets: Bitcoin and Ethereum experienced synchronous cycles of growth and decline throughout the studied period of 2017–2026 (*Figure 1*). The high value of the correlation coefficient (r =

0.922) indicates the presence of a common trend component, which may be driven by shared macroeconomic and market demand factors. At the same time, such a correlation may be partly due to the non-stationarity of the series and reflect a common trend rather than a direct structural link between the assets.

The correlation of *log* returns is a considerably more informative indicator, since first differences of logarithms are free of the trend component and close to stationary. The value of $r = 0.795$ indicates a strong but incomplete synchronicity of short-term (daily) price movements. This means that a substantial part of the variation in Ethereum returns is associated with Bitcoin dynamics ($R^2 \approx 0.632$), whereas the rest is attributable to Ethereum-specific factors: protocol updates, *DeFi* market dynamics, smart-contract activity, etc.

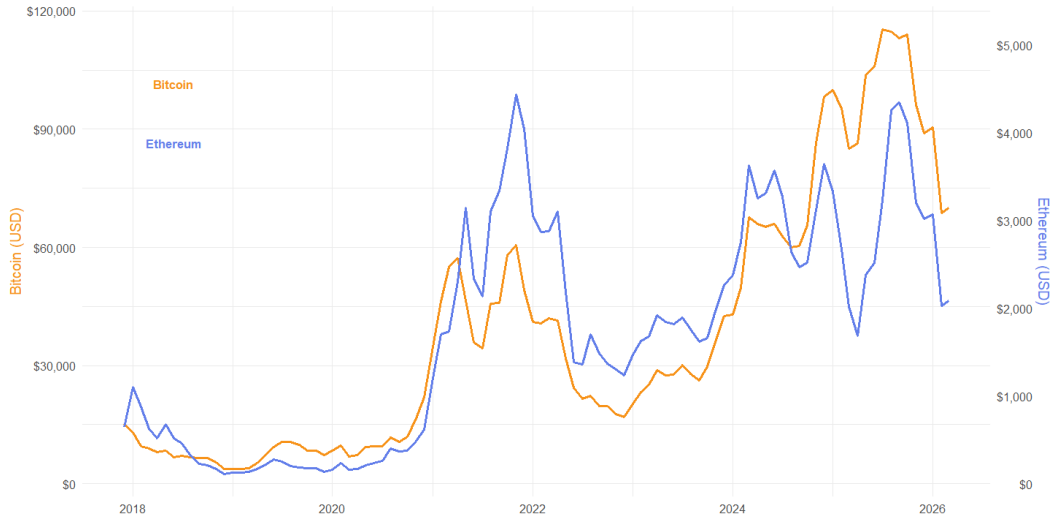


Figure 1. Synchronous movement of *Bitcoin* and *Ethereum* prices in 2017–2026

Source: constructed by the author in *R* based on Yahoo Finance data (n. d.).

The gap between the correlation values in levels (0.922) and in returns (0.795) reflects the presence of a common long-term trend alongside the preserved short-term autonomy of dynamics. This supports the hypothesis of partial complementarity (H3), since crypto assets function as elements of a single asset class in the long run but are not perfect substitutes in short-term dynamics.

From the standpoint of the duopoly market structure, the obtained value of the *log*-return correlation is compatible with different interaction mechanisms, including both price leadership (the Bertrand model) and a response to changes in market positions (the Cournot model). At the same time, correlation analysis does not allow causal relationships to be identified, which necessitates further regression analysis to disentangle these effects.

2. Analysis of the market shares of Bitcoin and Ethereum

The calculated annual average shares (*Table 1*) demonstrate the key structural characteristic of the duopoly under study, namely its deep and persistent asymmetry, which has not weakened over the past nine years of observation. It should be noted that the calculated shares reflect the relative ratio between BTC and ETH within a two-asset system, which is a deliberate choice in line with the logic of a two-player model, but it limits the extrapolation of the results to the broader crypto market.

Table 1

Dynamics of the market shares of Bitcoin and Ethereum

Year	Price share of Bitcoin	Price share of Ethereum	Trading share of Bitcoin	Trading share of Ethereum	Gap between the price and trading shares of *BTC*
2017	0.958	0.042	0.827	0.173	0.131
2018	0.945	0.055	0.728	0.272	0.217
2019	0.974	0.026	0.698	0.302	0.276
2020	0.974	0.026	0.698	0.302	0.276
2021	0.945	0.055	0.629	0.371	0.316
2022	0.934	0.066	0.667	0.333	0.268
2023	0.941	0.059	0.702	0.298	0.238
2024	0.955	0.045	0.662	0.338	0.293
2025	0.971	0.029	0.654	0.346	0.317
January–March 2026	0.970	0.030	0.645	0.355	0.325

Source: calculated by the author in R based on Yahoo Finance data (n. d.).

The price dominance of Bitcoin remains almost unchanged throughout the period: the share of *BTC* in the total capitalization of the two assets fluctuates within a narrow range of 0.934–0.974, whereas the share of Ethereum never exceeded 0.066. Despite the fact that ETH has reached technological maturity, moved to Proof-of-Stake, and become the base infrastructure of the DeFi ecosystem, its price weight in the system remains structurally limited. This indicates that, in price terms, the duopoly is a quasi-monopolistic structure rather than a balanced competition.

Trading activity shows a substantially different picture. The share of ETH in trading volumes rose from 0.173 in 2017 to 0.302–0.371 in 2019–2021 and stabilized at 0.338–0.355 in 2024–2026. That is, by the trading metric, Ethereum controls a third of the two-asset market, which is fundamentally different from its 3–6% price share. This divergence indicates that ETH is a much more actively traded instrument relative to its price weight and is used mainly as a liquid trading asset.

The data in *Table 1* clearly demonstrate the structural transformation of the trading weight of the two assets over 2017–2026 and constitute one of the key arguments in favour of the concept of an asymmetric duopoly.

Market formation phase (2017–2018). Ethereum entered the duopoly with a relatively low trading weight of about 17–27% of the combined trading volume of the two assets. Bitcoin dominated as the only widely recognized crypto asset, and most market activity was concentrated around it.

ETH growth phase (2019–2021). The share of Ethereum in trading volumes rose rapidly to 30–37%, peaking in 2021 amid the boom in DeFi, NFTs, and the overall growth of the smart-contract ecosystem. This is the only period when ETH approached a third of the market, which indicates the formation of a full-fledged second pole of the duopoly.

Stabilization phase (2022–2026). After Ethereum transitioned to Proof-of-Stake and the market turmoil of 2022, the share of ETH stabilized in the range of 33–36% and has not changed significantly since. This indicates that a structural equilibrium in trading activity has been reached: the duopoly has settled at a proportion of roughly 65/35 in favour of Bitcoin.

From the standpoint of duopoly models, *Table 1* confirms the validity of applying an asymmetric Cournot model: the players have different market power, and their shares are relatively stable over time rather than converging to a symmetric equilibrium. The stability of the shares over 2019–2026, despite radical changes in the technological and regulatory environment, is in itself consistent with the logic of a stable equilibrium, which is a key prerequisite for testing hypothesis *H*2.

The gap between the price and trading shares of BTC rose from 0.131 in 2017 to 0.317–0.325 in 2025–2026, i.e., by more than a factor of 2. This means that Bitcoin increasingly performs the function of a digital value reserve, that is, an asset that is held rather than traded, whereas Ethereum is shifting toward a liquid functional token. Such functional differentiation is direct empirical evidence of complementarity between the assets: they do not merely compete for the same demand but satisfy qualitatively different investor needs.

Consequently, the divergence between price and trading shares is empirical confirmation of functional differentiation between the assets. Bitcoin dominates as a store-of-value asset, whereas Ethereum holds a much stronger position as an instrument of circulation and use. It is precisely this differentiation that explains why the duopoly remains simultaneously asymmetric and stable: each asset dominates its own functional niche, which reduces the direct substitution effect and supports equilibrium.

3. Implications of the Bertrand model

The estimation results of the regression models (*Table 2*), which reflect the implications of Bertrand price competition, indicate a pronounced asymmetry in the interaction between Bitcoin and Ethereum.

Table 2

Estimation results of the models of price interaction between Bitcoin and Ethereum (Bertrand model)

Variables / indicators	Levels model (1)	Elasticity of ETH with respect to BTC (2)	Elasticity of BTC with respect to ETH (3)
Constant	–3.784*** (0.4579)	–0.0045 (0.0149)	0.0120 (0.0114)
ln(BTC)	1.063*** (0.0450)		
Δln(BTC)		0.9839*** (0.0859)	
Δln(ETH)			0.5820*** (0.0508)
Number of observations	100	100	100
R^2	0.850	0.573	0.573
Adjusted R^2	0.849	0.568	0.568

Note: standard errors are given in parentheses; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Source: calculated by the author in *R* based on Yahoo Finance data (n.d.).

The constructed levels model (1) shows an extremely close long-term relationship between the logarithms of the two assets' prices: the coefficient on ln(BTC) is 1.063 ($p < 0.001$), and $R^2 = 0.850$. This means that a 1% increase in the price of Bitcoin is associated with a 1.063% increase in the price of Ethereum in the long run. A coefficient above one indicates that Ethereum shows somewhat higher-than-proportional price sensitivity to changes in Bitcoin; that is, it amplifies the leader's impulses. The negative constant reflects a structural level discount of ETH relative to BTC, attributable to the difference in absolute prices.

The key results are obtained in the models of short-term dynamics. The elasticities are the central result of testing the Bertrand model and directly verify hypothesis *H*1 on asymmetric price leadership.

The elasticity of ETH with respect to BTC is 0.984 ($SE = 0.086$, $p < 0.001$), i.e., a 1% change in the monthly *log* return of *Bitcoin* is accompanied by a 0.984% change in the return of Ethereum in the same direction (*Figure* 2). The coefficient on Δln(BTC), close to one, means that ETH responds proportionally to a change in the price of BTC, which is behaviour characteristic of a market in which one player is the unrivalled price benchmark.

The elasticity of BTC with respect to ETH is 0.582 (SE = 0.051, $p < 0.001$), i.e., the symmetric dynamic is almost twice as weak as in model (2) (*Figure* 3). Thus, Bitcoin responds to price changes of *Ethereum* only partially, retaining considerable independence in forming its own price.

The values of the coefficients of determination ($R^2 \approx 0.57$) for both models (2) and (3) in first differences indicate that about half of the variation in short-term returns is explained by the interaction between the assets, whereas the other part is due to idiosyncratic factors. This is consistent with the earlier conclusions about the partial complementarity of the assets: despite the strong interrelation, Ethereum retains a degree of autonomy in short-term dynamics.

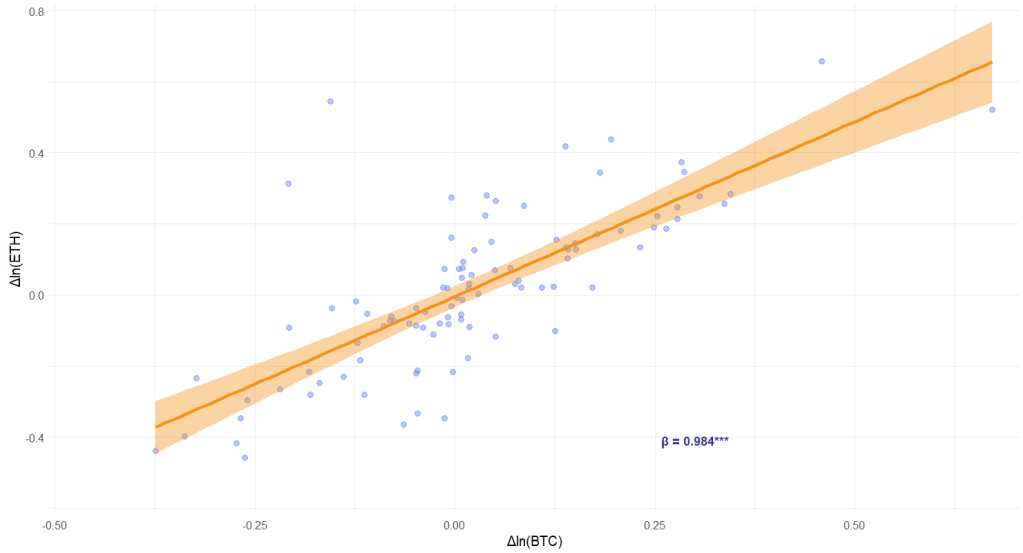


Figure 2. Elasticity model of *ETH* with respect to *BTC*

Source: constructed by the author in *R* based on Yahoo Finance data (n.d.).

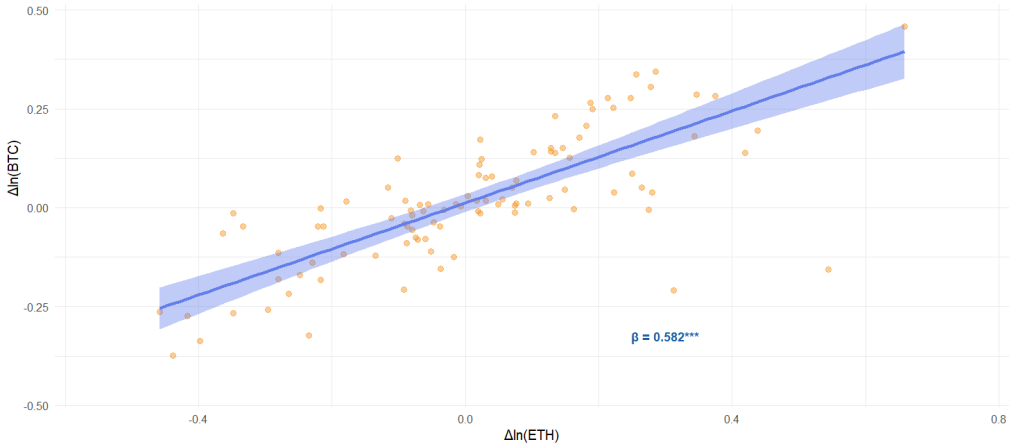


Figure 3. Elasticity model of *BTC* with respect to *ETH*

Source: constructed by the author in R based on Yahoo Finance data (n.d.).

The asymmetry of the elasticities (the difference between these coefficients is 0.402) is a quantitative measure of the asymmetry of price transmission and serves as direct empirical confirmation of the hypothesis of Bitcoin price leadership (H1) in the duopoly. The results obtained mean that price impulses generated in the Bitcoin market are almost fully transmitted to Ethereum, whereas the reverse effect is substantially weaker. From an economic standpoint, this corresponds to a hierarchical duopoly structure in which Bitcoin plays the role of the dominant player (leader) that sets market dynamics, while Ethereum acts as an adaptive follower. Such a configuration is consistent with an asymmetric interpretation of the Bertrand model, in which one of the players has greater market power and shapes the price expectations of the other participants.

Thus, the results of the empirical analysis confirm the presence of an asymmetric price transmission mechanism between Bitcoin and Ethereum and allow their interaction to be interpreted in terms of the Bertrand model with Bitcoin as the dominant price leader (confirmation of hypothesis H1), while Ethereum is a reactive follower with substantially lower price autonomy.

4. Implications of the Cournot model

The regression of the change in the market share of Ethereum on the lagged share of Bitcoin (model 4) yielded a statistically significant result ($p < 0.001$); however, the coefficient on $s_{BTC,t-1}$ deserves attention. It is +0.302 ($SE = 0.068$, $p < 0.001$); the constant is –0.205 ($p < 0.001$), *Adj*. $R^2 = 0.157$ (*Table 3*). The model explains 15.7% of the variation in changes in the *ETH* share, which is a low but significant result for monthly financial data.

Table 3

Estimation results of the Cournot model
(dynamics of the market shares of Bitcoin and Ethereum)

Variables / indicators	Δs_{ETH} (dependent variable)
Constant	–0.2046*** (0.0468)
$s_{BTC,t-1}$	0.3018*** (0.0685)
Number of observations	100
RMSE	0.0328
Adjusted R^2	0.157

Note: standard errors are given in parentheses; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Source: calculated by the author in *R* based on Yahoo Finance data (n. d.).

The classical Cournot equilibrium implies a negative coefficient β, i.e., if the *BTC* share in the previous period rises, the *ETH* share in the next period should decline as the competitor's reaction to the loss of its position. The positive coefficient obtained (+0.302) means the opposite: an increase in the *BTC* share precedes an increase in the *ETH* share in the following month. This directly contradicts the mechanism of quantity displacement and does not confirm hypothesis *H2* in its classical formulation. However, this result has a meaningful explanation in the context of crypto assets. Thus, an increase in the market share of *Bitcoin* generally occurs in a phase of overall market upswing, when capital flows into the entire asset class. During such periods, *Ethereum* also receives an inflow of investment with a one-month delay, which allows us to identify a rotation of capital from Bitcoin to altcoins, well documented in the crypto-finance literature (Kammoun, 2026; Zhang et al., 2024; Kumah & Baafi, 2025). Thus, the positive coefficient reflects not competitive displacement but complementary demand: BTC and ETH are mutually complementary elements of a single investment class, in which the growth of one asset stimulates interest in the other.

The result obtained also indicates that the standard Cournot model with a trading-volume share is an insufficiently adequate specification for

crypto assets. The trading-volume share reflects not the production decisions of players, as in the classical model, but trader behaviour, which is determined by market sentiment rather than strategic planning.

Therefore, the Cournot equilibrium hypothesis H2 in its standard formulation is rejected. Instead, the result supports the complementarity hypothesis H3: the dynamics of the digital assets' shares point to a synchronous rather than competitive movement. This does not contradict the general concept of an asymmetric duopoly but refines it, since competition between BTC and ETH is realized mainly through the mechanism of price leadership, whereas at the level of market shares the effect of a common asset class dominates.

Conclusions

The conducted study is an attempt to systematically verify the hypothesis of an asymmetric duopoly structure of the cryptocurrency market by empirically testing the implications of the Bertrand and Cournot models on Bitcoin and Ethereum data for 2017–2026. The results obtained allow the following conclusions to be formulated.

First, the correlation analysis of the logarithmic price series confirmed the presence of two qualitatively different levels of interdependence between the assets. The high correlation of *log* levels ($r = 0.922$) reflects a common long-term trend component, whereas the correlation of *log* returns ($r = 0.795$) indicates a strong but incomplete short-term synchronicity. The gap between these indicators (0.127) quantitatively captures the degree of Ethereum's specific autonomy, driven by factors of the *DeFi* ecosystem and protocol updates, and serves as the first empirical argument in favour of the partial complementarity hypothesis (*H3*).

Second, the analysis of market shares revealed a persistent structural asymmetry over nine years of observation. The gap between the price and trading shares of *BTC* more than doubled (from 0.131 in 2017 to 0.317–0.325 in 2025–2026), which indicates a deepening of functional differentiation: Bitcoin increasingly plays the role of a digital value reserve, whereas Ethereum is establishing itself as a liquid functional token. This differentiation is the key mechanism sustaining a stable equilibrium in the asymmetric duopoly: each asset dominates its own functional niche, which reduces the direct substitution effect.

Third, the results of testing the implications of the Bertrand model confirmed the hypothesis of Bitcoin price leadership (H1). The elasticity of ETH with respect to BTC is 0.984 ($p < 0.001$), whereas the reverse elasticity of BTC with respect to ETH is only 0.582 ($p < 0.001$). The asymmetry of 0.402 is a quantitative measure of BTC's dominance in setting price benchmarks: price impulses from Bitcoin are almost fully transmitted to Ethereum, while the reverse effect is twice as weak. The levels model ($R^2 = 0.850$) confirms a close long-term relationship with a coefficient of 1.063, which indicates that the follower amplifies the leader's impulses.

Fourth, testing the implications of the Cournot model revealed a statistically significant positive coefficient (+0.302, $p < 0.001$) on the lagged *BTC* share, which directly contradicts the classical mechanism of quantity displacement and refutes hypothesis *H2* in its standard formulation. Instead, the positive sign is interpreted as a manifestation of a mechanism of capital rotation from Bitcoin to Ethereum with a one-month lag: an increase in the BTC share is a harbinger of a bullish market phase, during which capital spreads to Ethereum as well. This result is an independent empirical contribution consistent with the altcoin-season phenomenon and confirms the complementarity hypothesis (*H3*).

Thus, the cryptocurrency market in the BTC–ETH segment functions as an asymmetric duopoly in which competition is realized mainly through the mechanism of price leadership, whereas at the level of market shares the effect of complementary demand dominates. The practical significance of the results lies in three aspects. For portfolio managers, the identified lag of capital rotation from BTC to ETH is an instrumentally significant signal when rebalancing crypto portfolios. For regulators, the persistent asymmetry of market shares and the price leadership of Bitcoin indicate a concentration of systemic risk in a single asset, which must be taken into account in approaches to the prudential regulation of digital assets. For researchers, the rejection of the Cournot model is evidence that classical industrial organization models require modification in order to describe cryptocurrency markets correctly.

Prospects for further research lie in extending the analysis and applying regime-dependent models to identify structural breaks, in particular those related to the approval of Bitcoin ETFs in 2024, as well as in constructing a dynamic version of the Cournot test to verify the stability of the identified capital rotation effects under different market conditions.

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ADAPTIVE CAPACITY OF UKRAINIAN FINANCIAL MARKET IN THE FACE OF MILITARY CHALLENGES

The article examines the current state of Ukraine's financial and credit system under conditions of profound structural shocks caused by the full-scale war, macroeconomic instability, energy-related risks, and the growing scale of cyber threats. The relevance of the study is determined by the fact that the country's financial system has become a central element of economic resilience, while its ability to function under crisis conditions directly affects the pace of recovery and the financial security of the state. The research hypothesis is based on the assumption that the adaptability of the banking system, the resilience of the insurance market, and the basic recovery of the stock market segment are possible even in an extremely adverse environment, provided that state regulators apply effective instruments of monetary, supervisory, and public debt policy. To test this hypothesis, a set of research methods was employed, including descriptive statistical analysis to assess the dynamics of key indicators, a comparative approach to identify structural changes in financial markets, and a systems analysis to reveal interconnections among individual institutions within the financial and credit system. The research findings indicate that the banking sector has maintained liquidity and profitability, the insurance market has demonstrated adaptability and premium growth, and the stock market, although remaining low-liquid, continues to play a stabilizing role in public financing. At the same time, a number of structural problems have been identified, including banks' dependence on government debt instruments, concentration

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АДАПТИВНІСТЬ ФІНАНСОВОГО РИНКУ УКРАЇНИ ДО ВОЄННИХ ВИКЛИКІВ

Досліджено сучасний стан фінансово-кредитної системи України в умовах глибоких структурних потрясінь, зумовлених повномасштабною війною, макроекономічною нестабіль¬ністю, енергетичними ризиками та зростанням кіберзагроз. Актуальність статті визначено тим, що фінансова система країни стала центральним елементом економічної стійкості, а її здатність функціонувати у кризових умовах безпосередньо впливає на темпи відновлення та фінансову безпеку держави. Висунуто гіпотезу, що адаптивність банківської системи, стійкість страхового ринку та базове відновлення фондового сегмента можливі навіть у надзвичайно несприятливому середовищі за умови, якщо державні регулятори застосовують ефективні інструменти монетарної, наглядової та боргової політики. Для перевірки цієї гіпотези використано комплекс методів: дескриптивний статистичний аналіз для оцінювання динаміки ключових показників, порівняльний підхід для визначення змін у структурі фінансових ринків, а також системний аналіз для виявлення взаємозв'язків між окремими інститутами фінансово-кредитної системи. Досліджено, що банківський сектор зберіг ліквідність і прибутковість, страховий ринок продемонстрував адаптивність та приріст премій, а фондовий ринок хоч і залишився малоліквідним, проте відіграє стабілізуючу роль у державному фінансуванні. Водночас виявлено низку структурних проблем: залежність банків від державного боргу, концентрацію страхового ринку, низьку активність

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within the insurance market, low activity of the corporate sector, and rising cyber risks. It is concluded that the further resilience of Ukraine's financial and credit system depends on the modernization of regulatory infrastructure, strengthening of institutional capacity, and harmonization with European standards.

Keywords: financial system, financial stability, banking, insurance, stock market.

корпоративного сектору та зростання кіберризиків. Встановлено, що подальша стійкість фінансово-кредитної системи залежить від модернізації регуляторної інфраструктури, посилення інституційної спроможності та гармонізації з європейськими стандартами.

Ключові слова: фінансова система, фінансова стабільність, банківська справа, страхування, фондовий ринок.

JEL Classification: G21, G01, E44, C23, H63.

Introduction

The financial and credit system of Ukraine operates under conditions of high uncertainty caused by war, macroeconomic instability, and escalating cyber risks. Martial law has significantly transformed the functioning of the banking sector: regulatory decisions by the NBU (2022, 24 February), particularly Resolution No. 18 of 24 February 2022 "On the Operation of the Banking System During the Period of the Introduction of Martial Law", ensured operational stability and liquidity support for financial institutions. According to the "Financial Stability Report" of the National Bank of Ukraine for June 2025 (NBU, 2025, June), the financial sector as a whole maintains resilience; however, interest rate, credit, and cyber risks are increasing, alongside the banks' growing dependence on state support. Data from the Ministry of Economy of Ukraine indicate a slowdown in investment activity and a deepening fiscal burden, creating additional pressure on financial institutions.

The issues surrounding the development of the financial and credit system are actively addressed in both domestic and foreign academic literature. The works of Zakharova (2023) analyse the specific features of financial management in times of war, while Prokopenko et al. (2023) examine the transformation of banking stability mechanisms under martial law. International analytical resources, notably Intellinews (2025, December 1), emphasise that the Ukrainian financial system maintains adaptiveness, yet faces an accumulation of systemic risks. Similar conclusions regarding the resilience of financial systems during periods of macroeconomic shock are also presented in international studies conducted by the International Monetary Fund and the World Bank (IMF, 2023; World Bank, 2022).

In the field of insurance, important data were provided by Forinsurer and XPRIMM (Magnaval, 2025, June 11), according to which insurance companies demonstrate stable operations in 2025 while remaining vulnerable to capitalisation reduction and risks associated with military actions. Despite a significant volume of research, existing academic literature lacks a comprehensive analysis of the combined impact of military, macroeconomic, and cyber threats across all segments of the financial and credit system as an interconnected structure.

The aim of the article is a comprehensive assessment of the state of the financial and credit system of Ukraine and the identification of the main challenges to its functioning under conditions of war and economic instability. To achieve this aim, the following tasks were set and addressed: to analyse the dynamics of the banking sector, the insurance market, and the capital market; to evaluate the role of state financial institutions and regulators; and to identify key risks and potential pathways for strengthening the resilience of the financial system.

In the course of the research, a hypothesis was formulated that the financial and credit system of Ukraine can maintain stability provided there is enhanced regulatory coordination, modernisation of institutional infrastructure, and adaptation of financial institutions to wartime challenges.

The methodological basis of the research is a combination of system and structural-logical analysis, a comparative approach, and statistical data processing of the NBU (2025, May 29), the Ministry of Economy, as well as banking and insurance reporting.

The main body of the article is structured into five sections based on challenges and key segments of the financial and credit system: the banking sector, insurance companies, the capital market, and state regulators, allowing for a comprehensive assessment of their resilience and role in the context of contemporary challenges.

1. Challenges facing the financial and credit system of Ukraine

Contemporary global challenges, particularly military threats, significantly impact financial management strategies in Ukraine. The armed aggression of the russian federation, economic instability, and security issues force enterprises to adapt their approaches to ensure financial resilience. War constitutes the most severe and dangerous trial for Ukraine’s financial sector and its elements, as, according to Zakharova (2023), the formulation of a development strategy during martial law should be viewed precisely through the lens of crisis management.

The main challenges facing the financial and credit system of Ukraine in 2026 include: the threat of a systemic collapse, an increased fiscal burden, devaluation of the national currency, reduction in investment and capital volumes, a labour market crisis, as well as a low level of public trust in financial institutions and the financial system as a whole. The latter is evidenced by the fact that a significant share of household savings is held outside the banking system in cash or foreign currency, reflecting a cautious attitude of households toward financial institutions. Furthermore, there is a marked escalation in cyber threats, the vast majority of which originate from russia.

Military risks, especially in the context of such a large-scale war of attrition, generate immense uncertainty for the financial and credit system.

They severely complicate the adoption of long-term financial strategies, shortening planning horizons to a single year. Four primary factors drive this high level of uncertainty:

- liquidity and solvency risk: due to military operations, economic entities face difficulties in maintaining liquidity and fulfilling their financial obligations;
- restricted access to financing: credit terms become tighter and at times unaffordable, thereby reducing investment activity to a minimum, as countries at war receive the lowest possible investment ratings;
- inancial losses of enterprises: the majority of large companies in Ukraine have suffered losses due to infrastructure destruction and asset loss, and continue to incur them as a result of shelling and targeted attacks on the energy sector;
- changes in foreign economic activity: military actions have significantly complicated export-import operations; the blockade of the Black Sea by the russian fleet and subsequent attacks on port infrastructure have particularly impacted the agricultural sector and large industrial enterprises reliant on maritime transport.

These factors create substantial obstacles to formulating an effective development strategy for the financial and credit system. Continuous fluctuations in energy costs, exchange rate volatility, and other external macroeconomic impacts induce market instability. Heightened inflationary pressure leads to a rapid increase in the prices of goods and services, which correspondingly drives down demand for non-priority product categories. Rising state expenditure on defense and infrastructure reconstruction, coupled with fiscal policy adjustments, increases the tax burden on businesses and the population. Under such conditions, maintaining the resilience of the financial and credit system and economic entities requires the establishment of adequate reserves and financial security mechanisms.

2. Banking sector

The banking industry in Ukraine has proven to be one of the most resilient sectors facing the challenges of full-scale war. The financial stability of banks is of pivotal importance for maintaining customer trust, ensuring economic stability, and complying with regulatory standards. In the context of the war with russia, banks continue to operate under restrictions established by Resolution No. 18 of the Board of the NBU dated 24 February 2022, "On the Operation of the Banking System During the Period of the Introduction of Martial Law" (NBU Board, 2022, February).

Under severe circumstances, the banking system of Ukraine managed to adapt while maintaining stability, and threats of large-scale bank insolvencies have not been observed. An important role in this was played by the experience of 2014–2017, when, following the onset of russian aggression, the banking system experienced a major crisis. However, that

period became a time of rehabilitation and cleansing from insolvent and distressed financial institutions. As a result, over 90 banks were withdrawn from the market by 2018 (*Figure 1*).

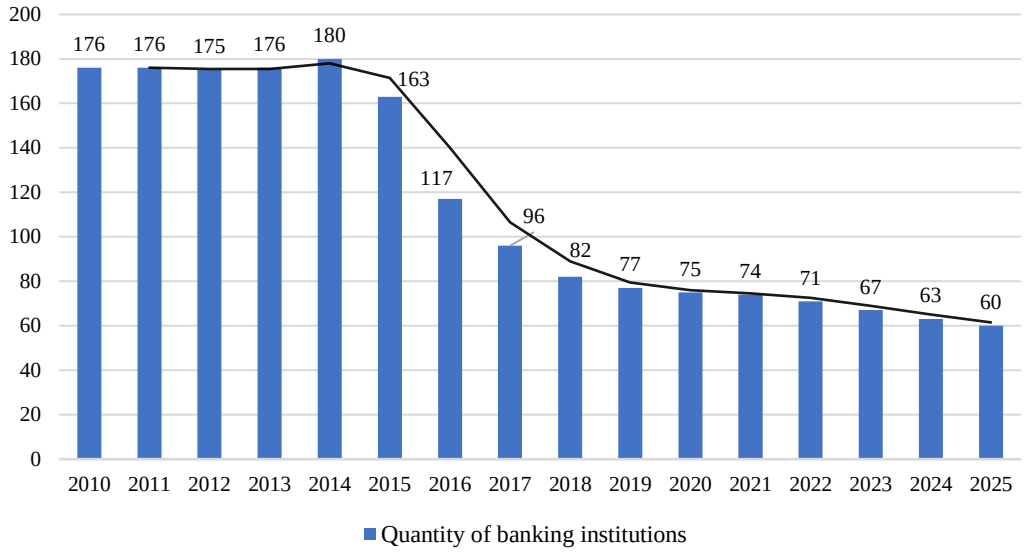


Figure 1. Quantity of banking institution in Ukraine for years 2010–2025.

Source: compiled by the author based on National Bank of Ukraine (n. d.).

According to NBU estimates in 2025 the banking system of Ukraine was characterized by stability and an adequate level of liquidity. Sector profitability remained high: net profit of banks reached approximately UAH 150 billion, which is roughly UAH 7–8 billion (around 5%) higher than in 2024. In spring, total client deposits in hryvnia across Ukrainian banking institutions reached a record figure of UAH 1.9 trillion. Consequently, the financial and credit system of Ukraine possessed a substantial and reliable foundation for expanding investment activity and lending to the economy.

Lending activity served as one of the key drivers of growth: a noticeable increase in lending volumes to both businesses and households was observed in 2025. According to NBU data, national currency business loans have been growing for more than a year and a half continuously, with their volume increasing significantly in 2025. Credit portfolio quality is gradually improving: the share of non-performing loans (NPLs) decreased by the end of 2025 to approximately 30.3%, which is 7.1 percentage points lower than at the beginning of 2024.

Additionally, an increasing share of government securities and liquid instruments in bank assets is observed – partly as a strategy to maintain yield and diversify risks under conditions of heightened uncertainty.

According to a survey of financial institution executives in May 2025 (NBU, 2025, May 29), the proportion of respondents expecting a deterioration in the sector's condition over the next six months dropped from 27% in November 2024 to 15% in May 2025. While the majority of experts

anticipated that the situation would remain stable, sentiments were becoming increasingly cautious.

The attractiveness of traditional deposits is partially diminishing due to inflationary processes and interest rate adjustments, prompting banks and clients to seek new financial models and instruments. In these circumstances, systemically important banks play a vital role in sustaining the stability of the banking system. In particular, PrivatBank remains one of the pivotal players in Ukraine's banking sector both by asset size and financial results. As of 2025, the bank's assets exceed UAH 1 trillion, accounting for approximately a quarter of total assets in the entire banking system. Strong financial performance among the largest banks, including PrivatBank, demonstrates the overall resilience of the banking sector and its capacity to function even amidst economic and security uncertainties.

These indicators demonstrate that despite external shocks (specifically war and economic instability), PrivatBank managed not only to maintain but to solidify its position. Lending activity played a crucial role in this process: the bank's loan portfolio grew by ~UAH 30 billion (+27%) during 2025, reaching UAH 143 billion by the end of September. Furthermore, PrivatBank's market share in loan issuance remains among the highest – almost 15% of the market – while its share in personal retail lending reaches approximately 35%. This indicates that the bank has not merely consolidated its standing, but currently serves as a key "provider" of credit resources to the economy and population – entailing corresponding risks, but also significant responsibility.

Substantially, PrivatBank also impacts the stability of the financial and credit system through the concentration of deposit resources: client funds in retail accounts grew to approximately UAH 505 billion, constituting over 22.9% of the total retail and corporate deposit market. This forms a solid "financial foundation" for active operations and, for the system as a whole, elevates PrivatBank's significance as a stabilizing element against the backdrop of wartime instability and economic shocks.

At the same time, a heavy concentration of assets, loans, and deposits within a single player presents a serious challenge to the financial system. Any crisis scenario associated with PrivatBank – whether market, operational, or cyber-related – could have systemic consequences. In this sense, the bank acts as a "point of systemic risk," a factor that regulatory bodies must account for when formulating financial stability and supervision policies.

Thus, in 2025 PrivatBank remained not just one of the main banks, but a foundational component of Ukraine's financial and credit system: a driver of lending, credit and deposit resources, and a source of a significant portion of system earnings. Its success or difficulties directly impact the resilience of the country's entire financial system. Therefore, considering wartime challenges, economic uncertainty, and post-war reconstruction needs, the role of PrivatBank can hardly be overstated.

In the current operational context of Ukraine's banking sector, characterized by the impact of military risks and macroeconomic instability, formulating recommendations aimed at enhancing its resilience and financial intermediation efficiency becomes particularly relevant. Based on the analysis of the state of the banking sector under martial law, the following recommendations are formulated to enhance its resilience and performance:

- further NPL reduction: a critical task remains the further reduction of non-performing loans by enhancing credit risk management mechanisms, debt restructuring, and developing the secondary NPL market, particularly for enterprises with recovery potential;
- asset diversification: to reduce bank reliance on state fiscal policy, it is advisable to incentivize asset structure diversification, limiting excessive concentration in government securities while creating conditions for expanding lending to the real economy;
- involvement in economic recovery: the banking sector should be more actively engaged in financing economic recovery processes, particularly through participation in state and international support programs for businesses and infrastructure projects;
- strengthening macro prudential supervision: given the systemic role of the largest, particularly state-owned, banks, macro prudential supervision must be reinforced through regular stress testing and higher capital, liquidity, and risk management requirements;
- enhancing cyber resilience: amidst growing cyber threats, bolstering the cyber resilience of the banking system is of paramount importance through the unification of security standards and harmonization of national requirements with European norms, particularly the DORA regulation (Official Journal of the European Union, 2022);
- financial literacy and public trust: long-term strengthening of the banking sector requires raising public financial literacy and trust in banking institutions, which will contribute to expanding the deposit base and securing resource stability.

The implementation of these measures will ensure the short-term stability of the banking sector and establish conditions for its effective participation in the post-war economic recovery of Ukraine.

3. Insurance sector

The insurance market, in turn, as one of the key elements of the financial and credit system, functions as a kind of "safety valve" for financial stability, providing both the mitigation of risk threats and the prompt compensation for their consequences.

Insurance companies accumulate substantial monetary resources in the form of insurance premiums and direct them toward investments in various assets – government bonds, corporate securities, shares, and other financial instruments. This facilitates the inflow of investments into the economy and supports the development of the financial market.

Consequently, economic entities can maintain the stability of their operations without incurring significant financial losses.

According to Ruda (2020), the insurance market represents a system of stable economic relations between policyholders, intermediaries, insurers, insurance sellers, and regulators. These interactions encompass the formation of supply and demand, pricing mechanisms for insurance and reinsurance products that operate within the framework of insurance, reinsurance, and related services at national and international levels, under state supervision.

In the first months of the war, insurance companies faced a series of significant challenges. The most tangible issues were related to employee relocation, the organisation of remote work, contract terminations, and delays in insurance pay-outs. The overall situation in the insurance market was exacerbated by a reduction in premium income, infrastructure destruction, and difficulties in conducting inspections of claim locations, particularly in regions of active hostilities.

At the same time, the experience accumulated during the COVID-19 pandemic enabled insurance companies to transition to remote working relatively quickly. Recommendations from the National Bank of Ukraine (Forinsurer) regarding the simplification of claim settlement procedures substantially facilitated adaptation to new circumstances and allowed for the preservation of operational continuity even under conditions of extraordinarily high uncertainty.

The insurance market of Ukraine today operates in two main segments: life insurance and risk insurance (non-life). The former segment comprises insurance companies that provide life insurance, whereas the latter includes companies offering services in property, medical, transport, and other types of risk insurance. Moreover, the insurance market remains profitable even under difficult conditions – growth in premiums and relatively stable claims payments indicate that insurance companies have successfully adapted to current realities.

According to industry reviews of the insurance market, in 2025 the insurance sector of Ukraine demonstrated a gradual recovery. Specifically, over the first 9 months of 2025, gross written premiums reached approximately UAH 52.7 billion, which is 37.5% higher than in the corresponding period of 2024. The primary share of the market is formed by non-life risk insurance – around UAH 48.4 billion, while life insurance accounts for approximately UAH 4.3 billion. The highest demand persists for auto insurance, health insurance, and property insurance products, reflecting the growing role of insurance as an instrument of financial protection for the population and business amidst military risks and economic uncertainty.

Simultaneously, the insurance market of Ukraine is characterized by a gradual increase in concentration. A significant portion of insurance premiums is accumulated by a relatively small number of the largest insurers: in particular, the top 10 insurance companies in the non-life segment account for over 70% of total insurance premiums (*Figure 2*). This trend is explained by tighter regulatory requirements concerning the financial stability of

insurers, increased capital requirements, and the gradual exit of less financially sound companies from the market.

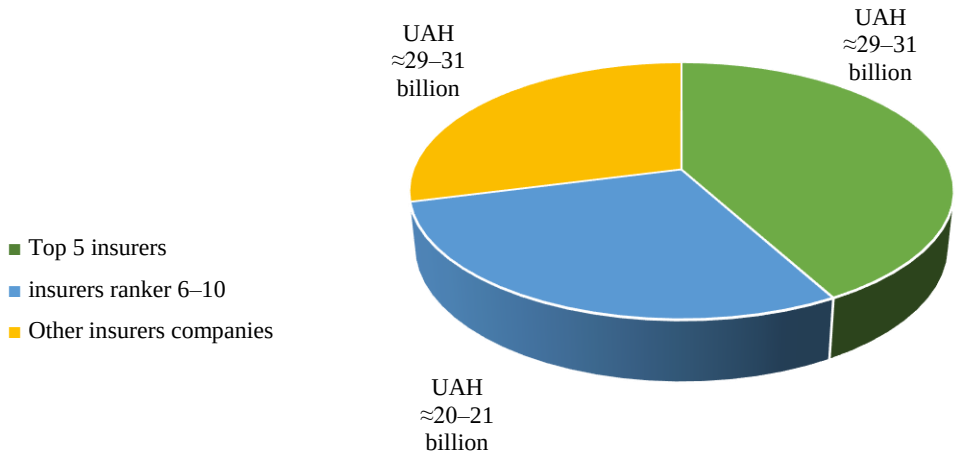


Figure 2. Concentration of the insurance market of Ukraine by groups of insurers in 2025, %

Source: compiled by the author based on data from the National Association of Insurers of Ukraine (2025).

In 2025, the insurance industry of Ukraine continued to be shaped by several large companies (National Association of Insurers of Ukraine, 2025) that concentrate the lion's share of the insurance market. Among the leaders are TAS, ARX Insurance Company, INGO, VUSO Insurance Company, and UNIQA Insurance Company. According to the international insurance analytical resource XPRIMM (Magnaval, 2025, June 11), over the three quarters of 2025, these companies collected the highest insurance premiums: TAS – UAH 5.717 billion, ARX – UAH 4.238 billion, INGO – UAH 3.830 billion, VUSO – UAH 3.728 billion, and UNIQA – UAH 3.572 billion.

However, beyond doubt, the scope of the insurance sector has been steadily shrinking over many years (Magnaval, 2025, June 11). Regarding insurance types, demand is growing primarily for risk insurance products – motor insurance (both mandatory and voluntary), health insurance, and property insurance. This indicates that insurance remains a vital element of financial protection for citizens and businesses amidst uncertainty.

Nonetheless, several serious challenges are observed. The reduction in the number of insurance companies signals that weaker players are exiting the market, partly due to heightened competition and partly due to difficult economic conditions (*Figure 3*). This increases concentration risk, which may weaken competition or limit consumer choice (see Figure 2). In the event of problems within one of the leading market players – caused, for instance, by mass insurance claims, large pay-outs, investment losses, or cyber incidents, which tend to increase in frequency – the consequences could become systemic. Therefore, for the resilience of the financial and

credit system, it is essential to maintain competition, market transparency, and adequate capitalisation of insurers, as well as to develop reinsurance mechanisms, diversification, and regulatory oversight.

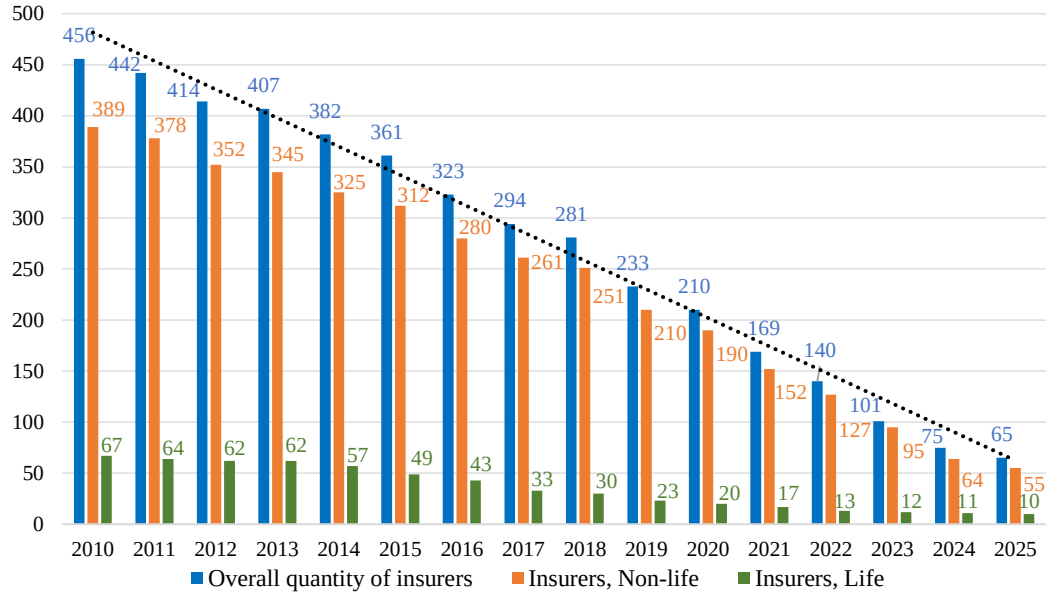


Figure 3. Dynamics of the number of insurance companies in Ukraine, 2010–2025

Source: compiled by the author based on National Bank of Ukraine (n. d.).

The analysis demonstrates that certain insurance segments (e. g., life insurance) are developing at a slower pace or even showing a decline in demand, which may reduce market diversification and leave it more vulnerable to fluctuations in individual sectors. High reliance on motor insurance and other non-life products is observed, which, amidst war and economic instability, increases the risk of reserve deficits or heightened volatility of losses. This, in turn, could undermine the stability of certain insurance companies. Furthermore, it should be noted that although citizens and businesses have lost a significant portion of insurable assets and continue to lose them as a result of Russian missile and drone attacks, even after the war ends, insurance expenditure will remain an unaffordable "luxury" for the majority of the population.

Based on the analysis of the state of the insurance market of Ukraine under martial law, it is advisable to define the following directions for its reinforcement:

- capitalisation and solvency: it is necessary to ensure an adequate level of capitalisation and solvency of insurers, particularly systemically important companies, in order to mitigate risks of financial instability;
- product diversification: expanding and diversifying insurance products is highly relevant, specifically through the development of life insurance and voluntary health insurance, which will contribute to forming long-term resources and reducing market concentration;

- reinsurance mechanisms: amidst escalating military risks, it is advisable to strengthen reinsurance mechanisms, including with the participation of international partners, to enhance the resilience of the insurance sector against mass claim pay-outs;
- transparency and consumer trust: enhancing operational transparency among insurance companies and elevating consumer trust remain essential, requiring stricter requirements for information disclosure and the protection of policyholders' rights;
- cyber resilience and digitalisation: given the digitalisation of financial services, bolstering the operational and cyber resilience of insurance companies is imperative, particularly through the harmonisation of national requirements with European standards.

The implementation of these measures will enhance the resilience of the insurance sector and reinforce its role within the financial and credit system of Ukraine.

4. Stock market

When analysing the situation on the stock market of Ukraine under wartime conditions, it is first appropriate to examine the number of active stock exchanges, as they serve as key platforms for securities trading. As of early 2021, Shyshkov (2021) notes that four stock exchanges operated fully in Ukraine: PJSC "Stock Exchange "Perspectiva"", JSC "PFTS Stock Exchange", JSC "Ukrainian Exchange", and PJSC "Ukrainian Interbank Currency Exchange".

According to the latest data from the NSSMC (2026), three stock exchanges officially functioned in Ukraine as of 2025: Ukrainian Exchange (UX), PFTS Stock Exchange (PFTS), and Perspectiva Stock Exchange. In 2025, the creation of a new stock exchange was initiated with state support and international partners, notably the European Bank for Reconstruction and Development (EBRD).

As a component of the financial and credit system, the stock market in 2025 primarily performed the role of a government borrowing market and a vehicle for stable investments. Through the issuance of government bonds and other debt instruments, the state and businesses raise financing to cover fiscal and infrastructure needs.

Securities and trading instrument markets in Ukraine demonstrate a gradual recovery in activity. Specifically, according to PFTS data, trading volume in January–September 2025 nearly doubled compared to the level of 2024 (*Table*). Institutional infrastructure is stabilizing: the regulatory framework is being updated, new rules for securities circulation are being introduced, and information disclosure procedures are being enhanced, contributing to increased market transparency. Trading in government bonds, Domestic Government Loan Bonds (OVDPs), and other fixed-income

instruments remains dominant in the market. According to PFTS data, government bonds account for a significant share of the trading structure.

However, the stock market is not yet fully capable of fulfilling its function as an effective mechanism for corporate financing and business development through equity capital raising due to low liquidity, weak demand for equity securities, and high uncertainty. This limits opportunities for investing in the real sector through the capital market.

Table

Dynamics of key indicators of the Ukrainian stock market for 2024–2025.

Indicator	2024	2025 (as of September)	Change
PFTS trading volume	≈ UAH 40–45 billion over 9 months	≈ UAH 77 billion over 9 months	+70–90% growth
Primary trading instrument	Domestic Government Loan Bonds (>95%)	Domestic Government Loan Bonds (>85%)	Unchanged: market remains dependent on debt securities
Equity traders' activity	Very low, isolated transactions	Very low, isolated transactions	Sector remains underdeveloped
Infrastructure changes	Regulatory changes were initiated	Ongoing updates to rules, transparency, and oversight	Gradual and slow improvement
Interest in new issuances	Absent due to War	Revival of interest, but no IPOs are conducted	Minimal potential for the future
Institutional investors	Very low activity	Still low, primarily state-owned banks and public financial institutions	High risks hinder the inflow of foreign capital

Source: compiled by the author based on (Holiuk et al., 2024; NSSMC, 2024).

Thus, the Ukrainian stock market currently serves more to support state financial flows and provide a "safe haven" for low-risk capital (Domestic Government Loan Bonds) than to stimulate active restructuring, private business growth, or long-term investment. Despite the war, attempts are observed to revive interest in equity and capital instruments: some companies are exploring avenues for initial public offerings (IPOs), and new opportunities – albeit carrying heightened risk – are emerging for investors. For the stock market to become a fully-fledged mechanism supporting economic growth and private enterprise, it is necessary to:

- enhance liquidity through attractive corporate issuances;
- attract investors, including international ones, and mitigate risks by improving the legal environment and investor protection;
- develop new financial instruments (investment funds, ETFs, corporate bonds);
- increase the transparency and efficiency of the exchange infrastructure.

If these steps are implemented, the stock market will transform into a crucial driving force for economic recovery and development, whereas

currently it primarily performs the functions of state financing and capital preservation. Similar conclusions regarding the role of capital markets in financing economic development are also present in modern international studies. Specifically, OECD analytical materials note that developed capital markets ensure enterprise access to long-term financing, promote the diversification of investment sources, and enhance economic resilience to crisis shocks.

5. State regulators

Under contemporary conditions, state financial institutions and regulatory bodies play a key role in ensuring the resilience of Ukraine's financial and credit system. The National Bank of Ukraine, the Ministry of Finance, the National Securities and Stock Market Commission, and the Deposit Guarantee Fund perform not only supervisory and control functions but also actively shape policies to adapt financial markets to the context of war and uncertainty.

Meanwhile, the Ministry of Finance of Ukraine remains a pivotal participant in the financial system, as a significant portion of budget financing is secured through Domestic Government Loan Bonds (OVDPs). Currently, the OVDP market primarily fulfils a stabilizing function, accumulating resources from banks and the public to support defence, social, and infrastructure spending. The state's heavy reliance on debt financing yields advantages in the form of predictable and liquid instruments; however, it also generates risks associated with the level of public debt, refinancing needs, and potential shifts in the structure of demand for debt obligations.

In the capital market, the NSSMC (2025) continues to implement policy aligning the regulatory environment with European standards. Nevertheless, despite reforms to disclosure requirements, supervisory mechanisms, and infrastructure standards, the stock market remains illiquid, dominated by government securities, with minimal activity in equity and corporate bond markets. This severely restricts opportunities for attracting private capital and complicates economic recovery through market mechanisms. At the same time, new regulatory initiatives (NSSMC, 2025) – including the development of the derivatives market, a modernized depository system, and harmonization with MiFID II and MiFIR – lay the groundwork for a potential revival of the capital market once the situation in the country stabilizes.

A formidable challenge for all regulators remains the rapid escalation of cyber risks and threats to the financial sector's information infrastructure. Cyber defence units, CERT-UA, and financial regulators report a significant expansion in the scale and sophistication of attacks. This forces state institutions to tighten security requirements for financial institutions, implement new security standards, conduct operational resilience stress testing, and coordinate efforts with international partners. Of particular relevance is the alignment of cyber resilience requirements with the

European DORA regulation (State Service of Special Communications and Information Protection of Ukraine, 2025, May) and the adaptation of sector infrastructure to a heightened threat environment.

Overall, state financial institutions and regulators remain foundational elements of Ukraine's financial and credit system, sustaining its stability and operation amidst severe turbulence. However, they also bear a substantial portion of strategic challenges: managing debt risks, modernizing capital market infrastructure, enhancing transparency, adapting to European norms, and countering cyber threats. The ability of the financial system not only to withstand current shocks but also to serve as a driving force for economic recovery and Ukraine's integration into the European financial space will depend on the efficacy of these processes.

Conclusions

The conducted study provided an assessment of the current state of Ukraine's financial sector under wartime challenges, identifying key risks and avenues for its further development. The analysis of the functioning of the banking sector, insurance market, and capital market demonstrated that Ukraine's financial system maintains institutional capacity for stable operation even under high macroeconomic uncertainty.

The most resilient element of the financial sector remains the banking system, supported by effective regulatory policy, adequate liquidity levels, and the active adoption of digital financial technologies. The insurance sector and the stock market exhibit a slower recovery due to reduced investment activity, elevated risks, and limited financial resources.

The study established that primary risks to the development of Ukraine's financial sector include credit risks, cyber threats, reduced solvency of economic entities, investment environment instability, and risks related to attacks on energy infrastructure and electricity deficits, which can impact the operational continuity of financial institutions, payment systems, and digital services.

Simultaneously, prospects for the development of the financial sector are linked to the digitalisation of financial services, the refinement of state regulation, the enhancement of institutional financial resilience, and integration into the European financial space.

Thus, the research hypothesis regarding the capacity of Ukraine's financial sector to maintain relative stability amidst military risks – provided there is effective regulation and institutional adaptation – is confirmed by the analytical findings.

To enhance the sector's financial resilience, it is advisable to:

- reinforce operational continuity requirements for financial institutions, specifically through the installation of backup power sources, data centre redundancy, and the development of cloud infrastructure;

• enhance risk management and cyber resilience systems within financial institutions, including the expansion of regulatory information security standards and the coordination of actions between state authorities and financial institutions.

The results obtained can serve as a basis for future research on financial resilience and the development of the financial sector during times of crisis.

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FINANCIAL ANALYSIS AND CONTROL OF PUBLIC PROCUREMENT

The article is devoted to the study of the phenomena of financial control, audit and analysis in the context of their use as part of the toolkit for regulating public procurement at the macro level of the state. Auditing of public procurement becomes one of the types of control by the state and guarantees the reliability of bidding. The development of social relations and the introduction of martial law in Ukraine sets its own requirements for public procurement and, accordingly, forms various control results. The relevance of the study lies in the need for state regulation of public procurement as a set of organizational, economic and legal methods and tools, general and specific, with the help of which interconnected functions are performed to ensure purposeful, continuous, effective influence of the state on processes and procedures in the country for the needs of sustainable functioning and development of the economy. The hypothesis of

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ФІНАНСОВИЙ АНАЛІЗ ТА КОНТРОЛЬ ПУБЛІЧНИХ ЗАКУПІВЕЛЬ

Досліджено феномени фінансового контролю, аудиту та аналізу в контексті їх використання у складі інструментарію регулювання публічних закупівель на макрорівні держави. Аудит публічних закупівель постає одним із видів контролю з боку держави і гарантує достовірність проведення торгів. Розвиток суспільних відносин і запровадження воєнного стану в Україні ставить свої вимоги щодо здійснення публічних закупівель і відповідно формує різні результати контролю. Актуальність дослідження полягає у необхідності вдосконалення державного регулювання публічних закупівель як сукупності організаційно-економічних та юридичних методів, а також інструментів, як загальних, так і специфічних, за допомогою яких виконуються взаємозв'язані функції для забезпечення цілеспрямованого, безперервного, ефективного впливу держави на процеси та процедури у країні для потреб сталого функціонування й

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the scientific study consists in justifying the importance of implementing the toolkit of financial control and analysis within the framework of a systematic, structured process of state regulation, optimized for Ukraine in view of the conditions of the external and internal environment (restrictions, problems and opportunities) that appear in order to promote the realization of the potential of the national economy. A system of measures aimed at improving financial control and analysis of public procurement is proposed. The authors of the article: developed a scheme of regulated measures aimed at improving financial control and analysis of public procurement; typical violations that arise as a result of public procurement audits are summarized and a model of risk audit organization and decision-making during public procurement is formed. The authors make proposals for the development of a system of measures aimed at improving financial control and analysis of public procurement, which ensure greater transparency, efficiency and honesty by improving the system of financial control and analysis at the level of procurement monitoring. The conducted scientific research is confirmed by statistical data, on the basis of the analysis of which conclusions were formed.

Keywords: public procurement, state regulation, financial control, audit, analysis, NATO standards.

розвитку економіки. Висунуто гіпотезу щодо важливості реалізації інструментарію фінансового контролю та аналізу в межах системного, структурованого процесу державного регулювання, оптимізованого для України з огляду на умови зовнішнього і внутрішнього середовища (обмеження, проблеми і можливості), що з'являються з метою сприяння реалізації потенціалу національної економіки. Запропоновано систему заходів, спрямованих на вдосконалення фінансового контролю та аналізу публічних закупівель. Розроблено схему регламентованих заходів, спрямованих на вдосконалення фінансового контролю та аналізу публічних закупівель; узагальнено типові порушення, що виникають за результатами проведення аудиту публічних закупівель та сформовано модель організації аудиту ризиків і прийняття рішень при проведенні публічних закупівель. Сформульовано пропозиції щодо розробки системи заходів, спрямованих на вдосконалення фінансового контролю та аналізу публічних закупівель, які забезпечують більшу прозорість, ефективність і чесність шляхом вдосконалення системи фінансового контролю та аналізу на рівні моніторингу закупівель.

Ключові слова: публічні закупівлі, державне регулювання, фінансовий контроль, аудит, аналіз, стандарти *НАТО*.

JEL Classification: M42, M48, H57, H83.

Introduction

Under the conditions of modern economic development, the state actively influences economic processes by regulating various areas, including public procurement. Under martial law, such intervention serves as a necessary regulatory mechanism that must ensure discipline in economic relations. State regulation of public procurement aims to ensure fairness, economy, and effectiveness in the use of public funds. In view of this, the scientific and practical issues of ensuring the effectiveness of state regulation of public procurement are becoming particularly relevant, primarily due to the large volume of financial flows associated with public procurement processes (and the related risks of corruption and other risks), as well as the need, arising from these risks, to ensure the conditions and means necessary to enhance the transparency, manageability, and efficiency of budgetary financial resource expenditure.

Under these circumstances, financial control, auditing, and analysis acquire particular importance as key instruments for ensuring the effective use of public resources in the field of public procurement (Nazarova, 2017), as they make it possible to assess the efficiency and effectiveness of procurement procedures, prevent abuse and corruption, and monitor compliance with legislation in this field.

As the volume and complexity of public procurement increase, and given the limited availability of budgetary resources, the relevance of which is significantly heightened by the need to conduct large-scale public procurement in Ukraine under martial law to meet the country's security and defence needs, the importance of researching financial control, auditing, and analysis as instruments of state regulation of public procurement (ProZorro, n. d.) is growing. Their effectiveness is crucial not only for achieving specific regulatory objectives but also for attaining the country's strategic goals, ensuring its defence capability, and maintaining its capacity to mobilise and allocate public funds to strategically important areas of financing critical societal needs.

The scholarly work of Ukrainian researchers has devoted considerable attention to investigating the specific features of and providing a scientific justification for an effective mechanism for managing the public procurement system, as well as overcoming organisational, economic, and legal constraints on activities in the field of public procurement, particularly in view of the current specific needs to adjust processes under martial law in Ukraine (Nazarova, 2017; Pedchenko, 2023).

Economists have demonstrated that ensuring the transparency and efficiency of procedures, providing adequate legal and organisational support, and establishing well-coordinated processes at all levels are important prerequisites for the stable development of the public procurement system and the country's economy as a whole (Zaiets, 2016; Okulich-Kozarin, 2021). At the same time, potential corrupt practices, methods for detecting them, and instruments of state oversight have not been sufficiently specified. Researchers emphasise the need to develop effective mechanisms for monitoring public expenditure and to conduct a systematic analysis of the efficiency and effectiveness of public procurement procedures.

The types and procedures of state regulation of public procurement have been studied and characterised in considerable detail (Vorovska & Kolesnyk, 2020; Horbatiuk, 2016; Zdyrko, 2019). At the same time, researchers do not specify in sufficient detail the measures to be undertaken by supervisory authorities, which limits the possibilities for an in-depth analysis of state oversight procedures in the field of public procurement.

The identification of types of public procurement is based on grouping and classification methods. Contemporary scholars devote considerable attention to investigating and systematising issues in this field, updating relevant approaches, and identifying ways to address problems related to abuse and violations in public procurement in Ukraine (Nazarova, 2017; Rusin, 2019). This represents a positive development in the study of public procurement procedures, but it does not specify financial control methods or the role of grouping and classification in the practical activities of auditors.

Given the dynamic changes in economic activity, particularly investment activity, in Ukraine amid russia's military aggression, as well as the specific features of public procurement under martial law, research into the theoretical and methodological foundations, problems, and prerequisites for improving financial control and analysis as important instruments for ensuring the transparency and effectiveness of the state regulation system for public procurement remains relevant and requires further scientific investigation.

The analysis of scholarly sources demonstrates that, despite positive developments in this area, certain aspects of the broader issue remain insufficiently addressed. These include optimising public procurement control mechanisms, developing and improving new control procedures in computerised data processing environments, coordinating the control functions of government authorities in the field of public procurement, and improving financial control methods in the context of public procurement, among other issues.

Particular attention should be devoted to developing a comprehensive approach to defining criteria for public procurement efficiency and establishing a link between the results of financial control and the achievement of the state's strategic objectives in this area.

These factors, together with the need to systematise issues related to financial control and analysis within the framework of state regulation of public procurement, identify key problems at the theoretical, methodological, and practical levels, and outline ways to address them, determine the relevance of the topic and shape the aim of the study.

The relevance of financial control over public procurement has increased significantly under the conditions of the full-scale war in Ukraine. Corruption is one of the most significant problems, alongside the consequences of russia's armed aggression, the rising cost of living, and declining household incomes. Particular attention must be paid to ensuring the transparency and efficiency of procurement for the needs of the Armed Forces of Ukraine and the Ministry of Defence of Ukraine, since the irrational use of budget funds in this area may negatively affect the provision of military personnel with the necessary resources and the country's defence capability.

During its monitoring of the Ministry of Defence of Ukraine, the National Agency on Corruption Prevention (NACP) identified a number of risks that contribute to corruption offences in the procurement of goods, works, and services for defence purposes. One of the main reasons for the prevalence of corruption is the lack of effective control over the intended use of budget funds received by suppliers as advance payments.

The aim of the article is to systematise and analyse approaches to financial control and analysis in the context of public procurement, identify their advantages and problematic aspects of financial control, and develop proposals for improving existing regulatory practices in this field.

To achieve this aim, the following objectives were set: to develop a scheme of regulated measures aimed at improving financial control and analysis of public procurement; to summarise typical violations identified through public procurement audits; and to develop a model for organising risk audits and decision-making in public procurement. In addition, particular attention should be paid to developing a comprehensive approach to defining criteria for public procurement efficiency and establishing a link between the results of financial analysis and the achievement of the state's strategic objectives in this area. Achieving the aim through the fulfilment of the specified objectives will contribute to improving the effectiveness of oversight of state regulation of public procurement and optimising the use of public resources, thereby preventing corruption and fraud schemes.

The research hypothesis is based on the assumption that the effectiveness of state regulation of public procurement can be enhanced by integrating financial control and analysis into a unified risk-based system supplemented by digital tools for monitoring and data analytics. It is anticipated that a shift from predominantly retrospective control and analysis towards a preventive, risk-based approach will facilitate the timely detection of violations and corruption risks, enhance the transparency of procurement procedures, promote the rational use of budget funds, and improve the effectiveness of state regulation of public procurement.

The theoretical and methodological basis of the study comprises systemic, process-based, and risk-based approaches to organising financial control and analysis of public procurement. The systemic approach was used to examine the interrelationship between public regulation, financial control, analysis, risk management, and procurement performance. The process-based approach was applied to investigate the sequence of control procedures at the main stages of the procurement cycle, from procurement planning to contract award and the evaluation of the results obtained. The following methods were used to systematise typical violations and risks: grouping, classification, and generalisation. The comparative analysis method was applied to compare different approaches to organising financial control and analysing the efficiency of public procurement. Economic and analytical methods were intended to be used to assess indicators of economy, efficiency, and effectiveness of procurement procedures.

The main body of the article consists of three sections. The first section focuses on the theoretical and praxeological aspects of applying financial control, auditing, and analysis within the scope of state regulation of public procurement. The second section analyses the results of state financial control over public procurement and proposes a systematisation of recommendations for its improvement. The third section examines the analysis of the results of state financial control over public procurement and the systematisation of recommendations for its improvement.

1. Theoretical and Praxeological Aspects of the Application of Financial Control, Auditing, and Analysis within the Scope of State Regulation of Public Procurement

Particular attention should be paid to the international practices of financial control over public procurement in the member states of the European Union (EU). Public procurement within the EU is governed by harmonised rules and procedures that are binding on all 27 Member States. These rules cover the procurement of goods, works, and services whose value exceeds a specified threshold and are based on the fundamental principles of equal treatment, transparency, and competition. They also comply with the provisions and principles of the Treaty on the Functioning of the European Union (TFEU) to ensure equal access to contracts for all tenderers. The European Commission (EC) actively participates in resolving disputes related to violations of procurement procedures and has extensive powers enabling it to initiate legal proceedings against Member States that fail to comply with EU rules. In the event of intervention, the Commission may require the Member State concerned to suspend the performance of a contract. If the country refuses to comply with this requirement, the institution is entitled to bring an action before the Court of Justice of the European Union, which may impose financial penalties on the country for each day of non-compliance with its public procurement obligations. No time limits are established for submitting complaints to the EC. The examination of a case may take three to four years or even longer. At the same time, in certain cases, the EC may implement interim measures more promptly following the results of control exercised by public authorities.

Public procurement conducted by European institutions differs from procurement procedures carried out by the authorities of the 27 Member States. Such processes are governed by specific rules and have a separate review mechanism. If companies encounter unfair treatment during a procurement procedure, they are advised to contact the relevant EU institution as promptly as possible to resolve the issue. Institutions are required to respond to all enquiries and complaints. Regulatory frameworks and financial control in the field of public procurement, both at the EU level and within its Member States, can be rather ambiguous, leaving room for discussion and further development of this research area, particularly with regard to the time limits for implementing decisions made by supervisory authorities (Ivanova & Sevostianova, 2018).

Within the US public administration system, authorised bodies operate in the field of procurement regulation and financial control, including the Office of Federal Procurement Policy and the Federal Acquisition Regulatory Council. The Office of Federal Procurement Policy is a structural unit of the Office of Management and Budget, which is part of the Executive Office of

the President of the United States. Its key tasks include monitoring federal procurement, coordinating rulemaking activities in this area, and ensuring the effective functioning of the regulatory framework. The Office of Federal Procurement Policy is responsible for developing and maintaining a unified system for regulating and controlling public procurement, resolving conflicts between government agencies, organising the activities of the Federal Acquisition Institute, and ensuring the operation of the Federal Procurement Computer System.

The Federal Acquisition Regulatory Council performs an interagency coordination function. The US public market for goods and services has two main segments: civilian goods and services representing traditional manufacturing industries, and military and technical products and services, as well as research and development activities. Under federal law, Congress and the President of the United States are authorised to place orders for all types of goods and services. To exercise this function, authority is delegated to federal departments, agencies, and government-owned business entities, which place orders through their own administrative structures based in Washington or through regional government offices located in the country's largest cities (Carpineti et al., 2006).

German legislation has a clearly defined structure in which the fundamental law is adopted as the principal legal document, while regulatory legal acts are enacted in accordance with its provisions. The articles of the fundamental law remain stable over long periods, whereas subordinate legislation is regularly adapted to changes in social and economic conditions. The principal legal instrument governing the procurement process in Germany is the Act against Restraints of Competition, which forms the core of the country's legal regulation of the market economy. It establishes the key principles governing the functioning of the competitive environment. This Act against Restraints of Competition has a long history of application, spanning more than forty years of development. As a Member State of the European Union, Germany complies with the provisions of EU procurement directives, which establish the rules for conducting international-level tendering procedures. This ensures that companies from all EU Member States have access to tendering activities, thereby promoting transparency and openness in procurement procedures. The federal states of Germany may additionally establish their own regulatory frameworks in this area. In the context of tendering policy, considerable attention is devoted to involving small businesses, which is of significant importance for long-term economic resilience.

Small businesses in Germany frequently win large-scale tendering procedures. The specific features of the country's legal framework help prevent market monopolisation by creating conditions for distributing contracts among different economic entities. For example, part of a supplier's or contractor's order may be subcontracted to another participant on the basis

of competitive pricing. This approach stimulates the development of small enterprises and fosters healthy competition without harming the national economy. Germany has a mechanism for monitoring potential risks arising from links between contracting authorities and monopolistic suppliers or contractors. This maintains a balance of power in the market and prevents the emergence of non-competitive cooperation models. Another important feature is the possibility of compensating participants for the costs of preparing tender documentation when such expenses are substantial (Ivanova & Sevostianova, 2018).

Financial control in the field of public procurement is a set of actions aimed at verifying and assessing the legality, efficiency, and effectiveness of the use of budget funds in the procurement process (Nazarova, 2017). Financial control in public procurement involves verifying the legality, appropriateness, and efficiency of public expenditure on the procurement of goods, works, and services.

In Ukraine, state financial control in the field of public procurement is exercised by the Accounting Chamber. In particular, a preliminary analysis is conducted of the annual report, which contains indicators of the functioning of the public procurement system and summarised information on the results of control in the procurement sector. Control in the field of public procurement is also exercised by the Antimonopoly Committee of Ukraine and the State Audit Service of Ukraine, a central executive authority responsible for implementing state policy in the field of state financial control (On Public Procurement: Law of Ukraine, 2015).

Financial analysis in the field of public procurement is the systematic examination of the financial position and financial results of procurement activities to assess their efficiency and develop recommendations for improvement (Horbatiuk, 2016; On Public Procurement: Law of Ukraine, 2015). Financial analysis helps assess the effectiveness of procurement procedures, identify potential risks, and develop measures to improve the efficiency of public procurement.

State regulation of public procurement is a distinct function of the state, implemented through an appropriate system of means, forms, methods, and instruments employed in the conscious and purposeful activities of the public administration apparatus. Financial control, auditing, and analysis constitute components of a comprehensive set of instruments for state regulation of public procurement and should therefore be regarded as specific types of regulatory activity aimed at the effective performance of particular state regulatory functions in a given field and at addressing specific problems. These functions include:

- *legal* (establishing the necessary legislative framework to ensure the transparency and efficiency of public procurement);
- *social* (ensuring the rights and freedoms of citizens by creating appropriate conditions for the implementation of public procurement);

• *economic* (ensuring the economic development of enterprises, economic sectors, and the national economy as a whole through the effective implementation of public procurement processes and procedures).

The need to apply financial control, auditing, and analysis within the scope of state regulation of public procurement stems from the fact that the economic relations (and, to a considerable extent, social relations) arising in the public procurement process often cannot be realised and developed in the direction determined by historical necessity and the state's objectives.

At the same time, state intervention in public procurement processes, as well as in the activities of economic entities associated with these processes, is driven under current conditions by the increasing complexity of economic relationships between business entities and the emergence of persistent crises in the economy at various levels, which necessitate state adjustment, coordination, and control.

State regulation of public procurement is a set of organisational, economic, and legal methods and instruments, both general and specific (including financial control, auditing, and analysis), through which interrelated functions are performed to ensure the purposeful, continuous, and effective influence of the state on public procurement processes and procedures in the country, thereby supporting the sustainable functioning and development of the economy.

The system of state regulation of public procurement consists of certain elements whose unity and interaction determine its purposefulness, efficiency, and functionality. The effective functioning of this system requires clearly defined goals and objectives, as well as the justification of specific forms and methods, areas of focus, and means of achieving these goals and objectives under the conditions prevailing in a particular country.

The implementation of forms of state regulation of public procurement is ensured through *methods* that exert a purposeful influence on public procurement processes and procedures and their participants in order to direct their specific activities towards the course required by the state and achieve the expected results (i.e. address specific problems). *According to the mode of influence*, public procurement regulation methods are divided into legal, economic, administrative, institutional, and socio-psychological methods (Zdyrko, 2019). *According to their duration*, they are classified as short-term and long-term. *According to the scale of state intervention* in investment processes, they are divided into general methods, which apply to the activities of any enterprise in any region, and selective methods, which concern only specific enterprises within a particular industry and region. *According to the nature of their influence*, public procurement regulation methods are divided into restrictive and incentive-based methods (*State Audit Service of Ukraine*, 2020). In addition to incentive-based and restrictive methods, there are also mixed methods of regulation that combine incentives and restrictions.

According to the level of influence, methods are divided into national, regional, and local methods (*rusin*, 2019). Methods of state regulation of public procurement are also differentiated into active and passive methods. Passive methods involve informing economic entities about the conditions of procurement procedures. They also include forecasting the country's economic development prospects and predicting the potential level of activity in the field of public procurement.

Given the wide range of instruments available for state intervention in public procurement processes and procedures, financial control, auditing, and analysis are considered in the context of the state's task of selecting the most effective combination of regulatory instruments, taking into account the specific circumstances of a particular country. Financial control, auditing, and analysis are among the priority instruments in this framework (Zaiets, 2016; Nazarova, 2017), as they are characterised by their effectiveness and potential to produce tangible results in influencing processes and procedures, as well as by a sufficiently developed legal, procedural, and organisational framework and a systematic approach. Therefore, the current system of financial control and analysis in the field of public procurement should be based on the following fundamental principles:

- *internal control* – exercised by public procurement contracting authorities;
- *external control* – conducted by state supervisory authorities, in particular the State Audit Service of Ukraine;
- *public oversight* – exercised by civil society organisations and the mass media.

An analysis of existing approaches to financial control and analysis in the field of public procurement has revealed a variety of methods and instruments used in this area. In particular, economically developed countries most frequently employ comprehensive control systems that encompass not only financial but also organisational and legal aspects. In countries with economies in transition, a greater diversity of approaches can be observed; however, the most widespread methods focus on auditing financial statements and internal financial control (Zdyrko, 2019; Okulich-Kozarin, 2023; ProZorro, 2024). The most effective systems are integrated control systems that combine financial, organisational, and operational control, enabling not only the detection of violations and inefficiencies but also the anticipation and prevention of their occurrence.

In the context of public procurement, the key aspects of financial analysis include:

- assessing the financial stability of participants in procurement procedures;
- analysing the efficiency and effectiveness of public expenditure;

- identifying and analysing risks associated with financial transactions within procurement procedures.

An important component of financial analysis in public procurement is the comparative assessment of different participants in procurement procedures using various financial indicators, such as liquidity, profitability, and financial stability (Okulich-Kozarin, 2021).

Equally important is the fact that an analysis of the current system of financial control and analysis has revealed a number of problems and shortcomings (Nazarova, 2017; Okulich-Kozarin, 2021) that limit the effectiveness of this system. These include a low level of transparency and accountability in public procurement, which undermines public trust in the system; the absence of a unified financial analysis methodology, which prevents comparisons between the results of analyses conducted by different supervisory authorities; insufficient effectiveness of internal control; limited powers of external supervisory authorities; and inadequate coordination among various supervisory authorities.

Given the identified problems, the following key measures are proposed to improve the system of financial control and analysis in the field of public procurement:

- strengthening oversight of compliance with public procurement legislation;
- developing and applying new control methods that will make it possible to assess not only the formal but also the actual efficiency of procurement;
- developing and implementing a unified financial analysis methodology that will enable comparisons between the results of analyses conducted by different supervisory authorities;
- strengthening internal control through the introduction of modern methods and technologies;
- improving coordination among various supervisory authorities and intensifying cooperation between bodies responsible for financial control in the field of public procurement;
- expanding opportunities for public oversight and improving the qualifications of employees of bodies responsible for financial analysis in the field of public procurement;
- increasing the transparency of the financial control and analysis system by expanding public access to information about control activities conducted and their results.

The implementation of the proposed procedures will make it possible to improve the effectiveness of financial control and analysis in the field of public procurement, thereby contributing to more efficient use of budget funds.

2. Analysis of the Results of State Financial Control of Public Procurement and Systematisation of Proposals for Its Improvement

The analysis of the results of financial control of public procurement conducted by the State Audit Service of Ukraine is summarised in *Table 1*.

Table 1

Dynamics of the Proportion of Violations of Public Procurement Legislation Relative to the Number of Enterprises, Institutions, and Organisations Subject to Control by the State Audit Service of Ukraine in 2020–2024

Indicators	2020		2021		2022		2023		2024	
	од.	%	од.	%	од.	%	од.	%	од.	%
Number of enterprises, institutions, and organisations subject to control (total), including:	6256	100	7631	100	8816	100,0	9286	100	7922	100
• audits	914	14.6	1002	13.1	440	5	702	7.6	744	9.3
• procurement inspections	97	1.6	466	6.1	472	5.4	357	3.8	354	4.4
• joint inspections	1	0	2	0	0	0	0	0	0	0
• procurement monitoring	5244	83.8	6161	80.7	7904	89.7	8227	88.6	6918	86.3
Violations of public procurement legislation detected (total), including:	9 041	100	9 104	100	8414	100	8 354	100	6 604	100
• audits	371	4.1	212	2.3	163	1.9	160	1.9	223	61.8
• procurement inspections	2	0.0	646	7.1	304	3.6	210	2.5	138	38.2
• procurement monitoring	8 668	95.9	8 246	90.6	7 947	94.4	7 984	95.6	0	0

Source: compiled by the authors based on data from the State Audit Service of Ukraine (2020), reports for 2020–2024.

An analysis of the dynamics in the number of enterprises, institutions, and organisations subject to control by the State Audit Service of Ukraine over the period 2020–2024 indicates a rapid increase in this figure. Thus, in 2021, compared with 2020, the number of enterprises, institutions, and organisations subject to control increased by 22%; in 2022, compared with 2021, this number increased by 15.5%; in 2023, compared with 2022, the number of enterprises, institutions, and organisations subject to control increased by 5.3%; and in 2024, compared with 2023, it decreased by 10%, respectively. This trend characterises the qualitative performance indicators of the State Audit Service of Ukraine and highlights its role in the system of financial control over the use of budget funds. Accordingly, the main forms of control over enterprises, institutions, and organisations included inspections (audits), procurement inspections, joint inspections, and procurement monitoring. Procurement monitoring accounts for the largest share of these activities and is an effective means of control during public procurement procedures. The dynamics of structural changes indicate only a change in their share of the total and confirm that the funds allocated from the state budget for conducting tenders were used in accordance with the requirements of current budget legislation. The violations of public procurement legislation detected constitute negative indicators of economic activity in the field of public procurement. From 2020 to 2024, these violations were characterised by a decrease of 7.2% (1).

$$\left(\sqrt[4]{\frac{9104}{9041}\cdot\frac{8414}{9104}\cdot\frac{8354}{8414}\cdot\frac{6604}{8354}}\right)\cdot 100 - 100 = -7.2. \quad (1)$$

Since 2022, violations of public procurement legislation have shown a downward trend, which has been attributed to the introduction of a moratorium

on inspections during martial law. The calculations performed demonstrate that the role of the State Audit Service of Ukraine in financial control over public procurement is not only confirmed by its necessity but also contributes to improving the effectiveness of explanatory activities, as evidenced by the indicators of the implementation of control results (*Table 2*).

Table 2

Dynamics of Management Decisions Made by the State Audit Service of Ukraine Based on the Results of Audits, Procurement Inspections, and Joint Inspections in 2020–2024

Indicators (index, name)	2020	2021	2022	2023	2024
01. Persons subject to disciplinary action	276	265	208	297	198
02. Persons held financially liable	343	274	179	199	346
03. Persons dismissed from their positions	19	45	21	22	16
04. Warnings issued regarding improper compliance with budget legislation, requiring the violation to be remedied	243	243	105	131	143
05. Budget allocations suspended	23	11	7	3	6
06. Transactions involving budget funds suspended	293	213	94	107	99
07. Budget appropriations / allocations reduced for budget fund administrators	33	17	14	19	7
08. Requirements issued for the return of subsidies and funds provided to budget fund recipients that had been used for purposes other than those intended	33	23	12	7	14
09. Requirements issued for the undisputed recovery of funds into the budget	0	0	0	0	0
10. Amounts recovered into the budget by the state fiscal service on the basis of materials provided by the State Audit Service	1	1	0	0	0
Total	1264	1092	640	785	829

Source: compiled by the authors based on data from the State Audit Service of Ukraine (2020), reports for 2020–2024, State Audit Service of Ukraine (2020).

The results of the analysis indicate that, from 2020 to 2024, the number of management decisions made by the State Audit Service of Ukraine based on the results of inspections, procurement inspections, and joint inspections showed a downward trend, decreasing by an average of 10% annually (2).

$$\left(\sqrt[4]{\frac{1092}{1264}\cdot\frac{640}{1092}\cdot\frac{785}{640}\cdot\frac{829}{785}}\right)\cdot 100 - 100 = -10. \quad (2)$$

The analytical data presented in *Table 2* for each type of management decision made by the State Audit Service of Ukraine based on the results of inspections, procurement inspections, and joint inspections over the period 2020–2024 indicate a significant downward trend. This outcome of the State Audit Service of Ukraine's activities is positive and serves as an instrument of state regulation of public procurement.

Summarising the results of the analysis, the authors of the article have systematised proposals for improving financial control, auditing, and analysis in the context of public procurement (*Figure 1*).

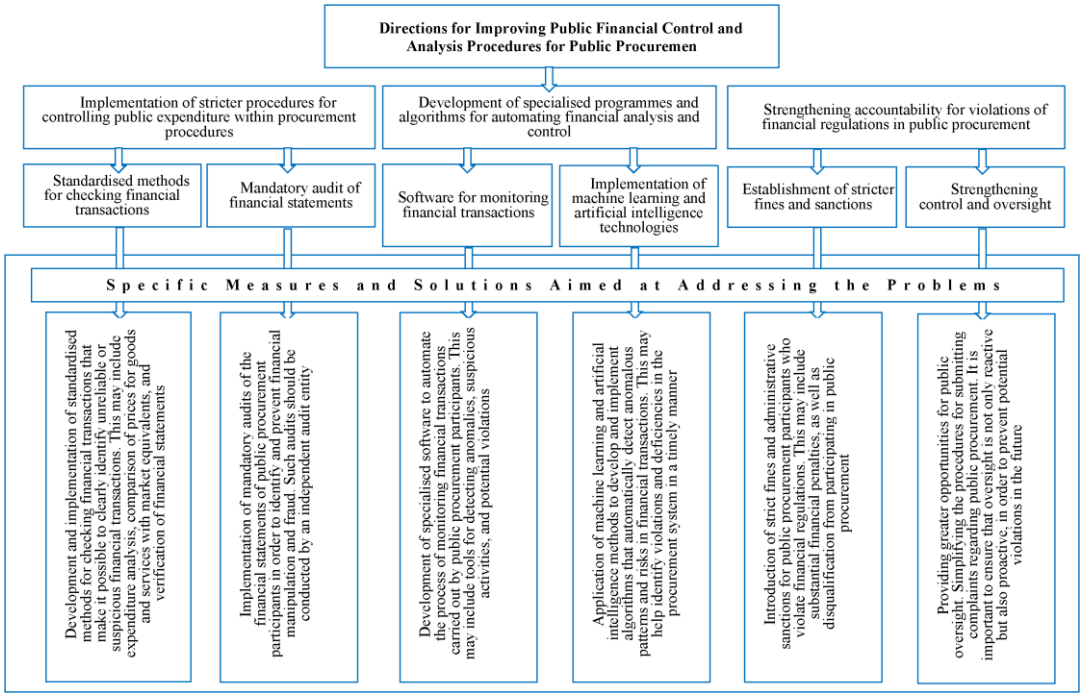


Figure 1. System of Recommended Measures Aimed at Improving Financial Control and Analysis of Public Procurement

Source: developed by the authors.

The results of the analysis should be grouped into three areas:

1) implementation of stricter procedures for controlling the expenditure of public funds within procurement procedures (developing and implementing standardised methods for auditing the financial transactions of participants in procurement procedures; introducing mandatory audits of the financial statements of participants in procurement procedures);

2) development of methodology and the design of specialised programmes and algorithms to automate financial analysis and control (creating software for the automated monitoring of financial transactions and the detection of anomalies in procurement procedures; implementing machine learning algorithms to predict risks and detect fraudsters in the field of public procurement);

3) strengthening accountability for violations of financial regulations in the field of public procurement (establishing stringent fines and administrative sanctions for participants in procurement procedures who violate financial regulations; strengthening oversight of the implementation of decisions and recommendations issued by supervisory authorities in the field of public procurement).

The proposed measures are aimed at ensuring greater transparency, efficiency, and integrity in public procurement by improving the system of financial control and analysis. This will make it possible to prevent losses of public funds resulting from financial violations and to strengthen public confidence, as well as the confidence of other stakeholders, in the public procurement process. Furthermore, these measures will contribute to improved financial resource management and increase the efficiency of budget fund

utilisation. The use of standardised auditing methods will reduce the risk of financial manipulation and abuse in the field of public procurement, thereby helping to ensure integrity and transparency in procurement procedures and reduce public expenditure on unscrupulous participants.

The application of machine learning methods and artificial intelligence technologies will make it possible to automate the process of detecting anomalies and violations in financial transactions, respond more promptly to potential violations, and minimise possible losses resulting from unscrupulous activities.

The introduction of stringent fines and sanctions for violations of financial regulations in public procurement serves as a preventive measure and creates a deterrent effect by discouraging violations of the law, thereby helping to reduce the number of violations and improve compliance with the law. Increasing the number of independent audits, which should be conducted to a high standard of quality, transparency, and impartiality, will contribute to strengthening control and oversight in the field of public procurement. This will make it possible to identify and remedy financial violations in a timely manner, while also creating conditions for more transparent and efficient use of public funds.

The proposed package of measures is aimed at addressing the need to improve financial management in the field of public procurement and ensure the efficient use of public resources. These measures will help strengthen public confidence in the procurement system and ensure more efficient and transparent implementation of government programmes and projects, particularly, at the current stage, those aimed at enhancing Ukraine's defence capabilities and its capacity to resist russia's military aggression against Ukraine.

3. Analysis of risks in public procurement under martial law and generalisation of audit results

Scientific studies indicate that risks are always present among participants in public procurement procedures during tendering. Timely identification and scientifically grounded, effective risk management are essential conditions for successful and transparent procedures. Under martial law, public procurement is characterised by constant changes in the regulatory framework. Furthermore, martial law has simultaneously created both advantages and disadvantages for public procurement, contributing to the emergence of risks. Timely risk analysis and auditing should not only identify negative factors but also help prevent them in order to enhance the transparency of public procurement.

At the same time, not all risks arising during the organisation of public procurement are associated with corruption (fraudulent) activities or non-compliance with current legislation. In some cases, the main causes include technical requirements, inadequate assessment of systemic performance, and other factors. *Figure 2* summarises a model illustrating how risks may arise in public procurement depending on their types. Meanwhile, *Table 3* groups typical violations identified through the results of operational audits (monitoring) of public procurement that give rise to practical risks.

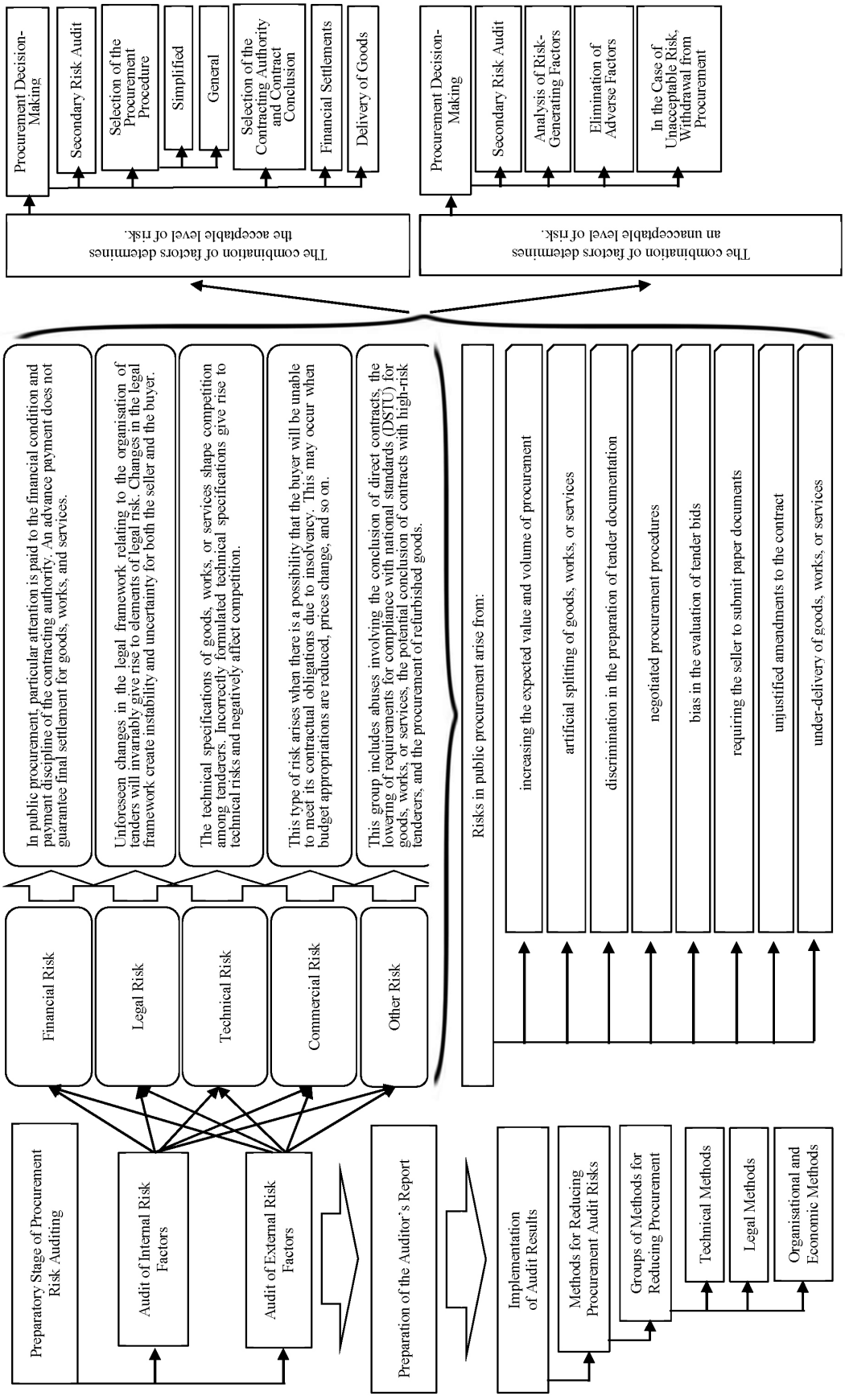


Figure 2. Model for Organising Risk Auditing and Decision-Making in Public Procurement

Sourse: (developed by the authors)

Table 3

Typical violations identified as a result of public procurement audits

Violation Group (Type)	Primary Documents Subject to Audit	Interpretation of the Violation
Unjustified planning of public procurement	Contracts; tender participation applications; documents confirming the tenderer's compliance	Absence of regulatory legal documents that are mandatory for use in determining the expected cost of a good, work, or service.
Exceeding the average market purchase price	Price quotations; cost estimates	Excessive pricing of goods, works, or services in public procurement may indicate corruption or fraud.
Failure to fulfil contractual obligations	Contracts; bank statements	Various types of risks may arise during the performance of contractual obligations, potentially prompting the contracting authority (seller) to fail to fulfil the terms of the contract.
Significant overestimation of procurement volumes	Contracts; bank statements	In this case, a corruption risk arises, consisting in the improper determination of procurement volumes and the receipt of an undue benefit.

Source: grouped by the authors.

Thus, public procurement auditing serves to determine the justification, feasibility, and efficiency of procurement, analyse tender results, and assess the compliance and reliability of the objectives stated in the Law of Ukraine "On Public Procurement" Public procurement auditing will be effective if it is conducted through a systematic combination of audit procedures, namely: documentary examination, which involves analysing documents relating to procurement procedures in order to verify compliance with current legislation and the proper organisation of procurement; and on-site inspection, which is carried out to ensure that tendering is conducted in accordance with the specified documents and the requirements of current legislation.

Since October 2022, the public procurement system in Ukraine has operated in accordance with Resolution No. 1178 of the Cabinet of Ministers of Ukraine (12 October 2022). In July 2024, Resolution No. 782 of the Cabinet of Ministers of Ukraine (4 July 2024) came into force. Accordingly, when procuring goods (works or services), the localisation requirement must currently be applied when an individual item included in the list of goods subject to localisation, which the contracting authority acquires, costs UAH 200 000 or more. Where several different items of goods are procured, the cost of each item must be considered separately. In addition, Clause 13 of the Special Provisions, which concerns the conclusion of a procurement contract without conducting open tendering and/or using an electronic catalogue, has been expanded. Specifically, it covers the procurement by contracting authorities of goods and services (except for routine repair services) valued at UAH 100 000 or more, routine repair services valued at UAH 200 000 or more, and works valued at UAH 1.5 million or more.

According to the Ministry of Economy of Ukraine, in 2023, the number of procurements completed in the Prozorro system increased by 28% compared with 2022, reaching 3.6 million lots. The expected value of

procurement increased by almost 70% compared with the previous period, reaching UAH 622 billion. Despite the full-scale war, the public procurement sector is currently developing more dynamically than ever. The year 2025 demonstrated that approximately 80% of all public procurement funds are spent through Prozorro. Thus, not only the number of procurements but also their success rate and the level of competition have increased. In 2022, successful procurements accounted for 60%, while in 2023, this figure reached 68%. The level of competition in 2022 was 1.8, representing the average number of bids per procurement (Bihun, 2024).

The increase in the number of completed procurements leads to an increase in the number of violations detected. The following violations were identified as a result of procurement procedures:

- violations of tender documentation requirements;
- violations of procedures for reviewing tender documentation;
- failure to publish official information, among others.

In its reports, the State Audit Service of Ukraine provides statistics on the main types of violations identified during public procurement audits (*Figure 3*). All violations identified by auditors in Prozorro should be grouped into nine categories, with a tenth additional category entitled "Other Violations".

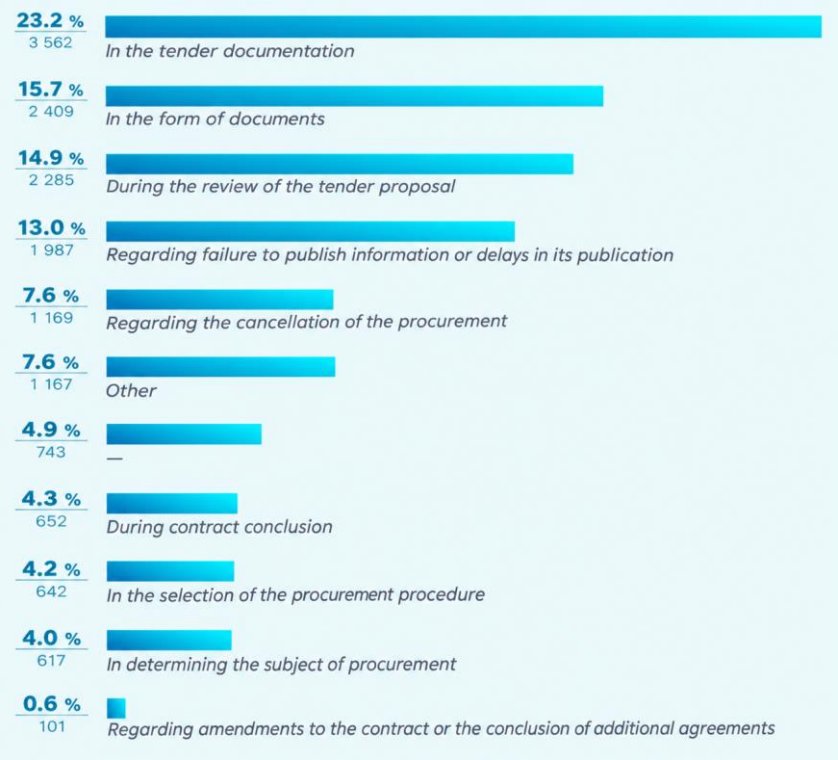


Figure 3. Classification of Violations Identified by the State Audit Service of Ukraine in the Audit of Public Procurement in 2023.

Source: State Audit Service of Ukraine. Reports (2020); Statistical Reports (2023).

Almost every fourth violation identified by the State Audit Service of Ukraine during public procurement procedures concerns "Violations in Tender Documentation"; every sixth violation concerns "Violations in the Tender Bid Evaluation Procedure" and "Violations in Document Formats." Together, these account for half of all violations identified during monitoring. There were 743 cases in which either no violations were found or the monitoring process was still marked as "Monitoring in Progress."

Conclusions

This study focuses on enriching the scientific understanding of contemporary organisational, economic, and legal processes and procedures involved in state regulation of public procurement through the use of appropriate control and analytical instruments. Given the wide range of instruments available to the state for influencing public procurement processes and procedures, financial control and analysis should be considered in the context of the state's task of selecting the most effective combination of regulatory instruments in view of the specific circumstances prevailing in a particular country. From this perspective, financial control and financial analysis are among the priority instruments within this framework, as they are characterised by their effectiveness and potential to influence processes and procedures, as well as by a sufficient degree of legal, procedural, and organisational development and systematic application.

The article establishes that improving the system of financial control and analysis will contribute to greater efficiency and transparency in public procurement, enhance the effectiveness of the state regulation system in this field, and help prevent abuse and corruption.

A synthesis of the research findings indicates an increase in the number of violations in the procurement system under martial law, as confirmed by official reports of the State Audit Service of Ukraine. Procurement monitoring has identified the main types of violations, including violations in the preparation of tender documentation; violations of procedures for reviewing tender documentation; violations relating to the publication of official information; violations in contract conclusion; and violations in the selection of procurement procedures, among others. Further synthesis and classification of these types of violations will make it possible to identify relationships between the areas in which budget funds are used and the types of fraudulent and corrupt schemes.

In July 2024, the Government of Ukraine amended the procedure for conducting public procurement in order to enhance the security of tenderers and protect procurement data from the enemy. Thus, it became permissible not to publish information about procurement for the country's defence needs and not to disclose the locations of supplier enterprises. The confidentiality of information during procurement for defence purposes at the monitoring stage may have a negative impact on tenders, particularly by creating opportunities for shadow schemes involving the expenditure of budget funds. An analysis of violations related to public procurement, based on data from the State Audit Service of Ukraine, makes it possible to identify the causes

of their occurrence. The authors suggest that such violations may stem from corrupt and fraudulent schemes involving the expenditure of budget funds, which can be detected through documentary cross-checks.

It is proposed that a system of measures aimed at improving financial control and analysis of public procurement at the procurement monitoring stage be developed. These measures should aim to ensure greater transparency, efficiency, and integrity in public procurement by improving the system of financial control and analysis. This will make it possible to prevent the loss of public funds due to financial violations and strengthen public confidence, as well as that of other stakeholders, in the public procurement process.

The results of the study are of scientific value, as they expand the range of theoretical foundations of financial control and analysis within the system of state regulation of public procurement, diagnose problems and shortcomings in the existing system of financial control and analysis, and provide specific proposals for improving this system. These results are also of practical significance, as they can be used to optimise the work of supervisory authorities, enhance the efficiency and transparency of public procurement, and improve legislation and the regulatory framework in the field of public procurement. The findings of this study are expected to contribute to a deeper understanding of the importance of financial control and analysis in ensuring the efficiency and transparency of public procurement.

Further research on this topic involves improving audit procedures for public procurement audits based on documentary cross-checks and analysing the dynamics of violations identified by state supervisory authorities. The latter will make it possible to identify the overall trends in the structure of abuses and assess their impact on certain macroeconomic indicators of the country. Further research should include an analysis of the results of control measures in the field of public procurement during the post-war period and their impact on the scale of the misuse of budget funds. Another promising area of research is the study of opportunities for implementing NATO standards and principles in Ukraine's public procurement system, particularly with regard to transparency, accountability, competition, and control over the use of resources. An important task is to identify mechanisms for adapting the relevant approaches to the national system of financial control and procurement auditing. This will help enhance the reliability of procurement procedures, strengthen control over the use of public funds, and bring Ukraine's public procurement system closer to the practices of NATO member states.

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PROACTIVE DIGITAL MARKETING OF EDUCATIONAL SERVICES

The relevance of this study is driven by the transformation of digital marketing in higher education under the influence of advances in artificial intelligence, data analytics, digital platforms, and increasing competition among universities to attract and retain students. The study is based on the hypothesis that the effectiveness of proactive digital marketing is ensured by the synergy of forecasting, personalization, monitoring, automation, and managerial decision-support mechanisms, whose interconnected functioning is enabled by the integrative role of artificial

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ПРОАКТИВНИЙ ЦИФРОВИЙ МАРКЕТИНГ ОСВІТНІХ ПОСЛУГ

Актуальність дослідження зумовлена трансформацією цифрового маркетингу у сфері вищої освіти під впливом розвитку штучного інтелекту, аналітики даних, цифрових платформ і посилення конкуренції між університетами за залучення та утримання здобувачів освіти. Дослідження ґрунтується на гіпотезі, що результативність проактивного цифрового маркетингу забезпечується синергією механізмів прогнозування, персоналізації, моніторингу, автоматизації та підтримки прийняття управлінських рішень, взаємопов'язане функціонування яких забезпечується інтеграційною

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intelligence. The methodological framework is based on systemic, structural-logical, comparative, and conceptual approaches. The study employs methods of scientific generalization and systematization, comparative analysis, content analysis of the practices adopted by leading universities worldwide, conceptual modelling, and graphical visualization. The findings conceptualize proactive digital marketing of educational services as an integrated stakeholder engagement management system based on the proactive identification of stakeholder needs, behavioral prediction, personalized digital engagement, monitoring of students' learning pathways, communication automation, and information-analytical support for managerial decision-making. The study demonstrates that the effectiveness of proactive digital marketing depends not on the number of implemented digital technologies but on the degree of integration, coherence, and synergy among its managerial mechanisms. A managerial mechanism synergy function and an artificial intelligence integration function are proposed, whose interaction explains the transition from a reactive to a proactive digital marketing model. Artificial intelligence is identified as a systemic integrator of forecasting, personalization, monitoring, automation, and managerial decision-support mechanisms within a unified management cycle. The practical significance of the research lies in the applicability of the proposed conceptual framework to the development of universities' digital marketing strategies, the assessment of digital maturity and organizational readiness for artificial intelligence implementation, and the further development of an integrated index for assessing proactive digital marketing in higher education institutions.

Keywords: educational services; higher education institution; digital transformation; digitalization; proactive digital marketing; artificial intelligence; AI-driven marketing; stakeholder engagement management; personalization; information and communication system; strategic management; automation; synergy; integration; innovation; competitiveness.

роллю штучного інтелекту. Методологічну основу дослідження становлять системний, структурно-логічний, компаративний і концептуальний підходи; застосовано методи наукового узагальнення та систематизації, порівняльного аналізу, контент-аналізу практик провідних університетів світу, концептуального моделювання і графічної візуалізації. За результатами дослідження проактивний цифровий маркетинг освітніх послуг концептуалізовано як систему стратегічного управління взаємодією зі стейкхолдерами, що ґрунтується на випереджальному виявленні їхніх потреб, прогнозуванні поведінки, персоналізації цифрової взаємодії, моніторингу освітніх траєкторій, автоматизації комунікацій та інформаційно-аналітичній підтримці прийняття управлінських рішень. Обґрунтовано, що його результативність визначається не кількістю впроваджених цифрових технологій, а рівнем інтегрованості, взаємоузгодженості та взаємопідсилення управлінських механізмів. Запропоновано функцію синергії управлінських механізмів і функцію інтеграції штучного інтелекту, взаємозв'язок яких пояснює перехід від реактивної до проактивної моделі цифрового маркетингу. Штучний інтелект визначено як системний інтегратор механізмів прогнозування, персоналізації, моніторингу, автоматизації та підтримки прийняття управлінських рішень у межах єдиного управлінського циклу. Практичне значення отриманих результатів полягає у можливості їх використання для формування цифрових маркетингових стратегій університетів, оцінювання цифрової зрілості та організаційно-управлінської готовності до імплементації штучного інтелекту, для подальшого розроблення інтегрального індексу проактивного цифрового маркетингу закладів вищої освіти.

Ключові слова: освітні послуги, заклад вищої освіти, цифрова трансформація, цифровізація, проактивний цифровий маркетинг, штучний інтелект, маркетинг на основі штучного інтелекту, управління взаємодією зі стейкхолдерами, персоналізація, інформаційно-комунікаційна система, стратегічне управління, автоматизація, синергія, інтеграція, інновації, конкурентоспроможність.

JEL Classification: I21, M31, O33.

Introduction

The digital transformation of the economy and the rapid development of information and communication technologies, artificial intelligence (AI), digital platforms, business models, and services have brought about a transition to a new stage of socio-economic development, in which digital

technologies have acquired the status of a key driver of economic growth, innovation, and increased competitiveness of business entities. Under these conditions, digitalization extends beyond the technological modernization of individual business processes and evolves into a comprehensive strategic management model that integrates digital solutions into all functional areas of an organization's activities, ensuring the development of new mechanisms for value creation, stakeholder engagement, and sustainable development.

One of the areas undergoing the most extensive and systemic changes under the influence of digital transformation is education. In accordance with the provisions of the Digital Education Action Plan 2021–2027, the European Commission defines digital education as the use of digital technologies, tools, and content to support learning, teaching, assessment, and the management of educational activities, while identifying the development of a highly effective digital education ecosystem as one of the strategic priorities for the development of the European Union (European Commission, n. d.). In this context, the digital transformation of education is not limited to the technological modernization of the educational process but involves the comprehensive development of digital infrastructure, enhancement of the digital competencies of participants in the educational process, introduction of innovative models of communication and interaction among stakeholders, and creation of an integrated digital environment capable of ensuring accessibility, personalization, adaptability, and continuity of education while laying the groundwork for its innovative development.

At the same time, the education services market is undergoing significant transformations. Intensifying global competition among universities, the internationalization of higher education, demographic changes, the expansion of academic mobility, and the development of digital platforms and AI technologies are substantially changing the conditions, principles, and mechanisms governing the operation of higher education institutions. Whereas their competitive advantages were traditionally determined primarily by the quality of educational programs, academic reputation, and human resources, under current conditions, the quality of digital interaction with stakeholders, personalization of communication, digital reputation, the accessibility and convenience of digital services, and the effectiveness of data collection, integration, and analytical use are becoming increasingly important. These processes are also transforming the behaviour of prospective higher education students. Decisions regarding university selection are increasingly shaped by the digital experience of interacting with an educational institution and by information obtained through official websites, social media, international and national rankings, online reviews, recommendation services, and other digital communication channels.

According to an international study by Spark451 & Jenzabar, which involved more than 1 800 high school students and 1 400 parents, 93% of prospective applicants use social media as one of their primary sources of information about universities, while 30% use generative artificial

intelligence (GenAI), primarily ChatGPT, when selecting a higher education institution (Spark451 & Jenzabar Company, 2025, October 1). These findings reflect fundamental changes in the information behaviour of prospective students. According to the Pew Research Center, in 2024, 90% of Generation Z members used YouTube, 63% used TikTok, and nearly half were online almost constantly, indicating the dominance of digital communication channels in the processes of information search, evaluation, and decision-making (Pew Research Center, 2024, December 12).

These trends are also confirmed by materials from Quacquarelli Symonds (QS), according to which a university's official website, social media, digital reputation, online reviews, personalized communications, and digital services are among the key factors influencing prospective applicants' choice of a higher education institution (QS, 2025, June 12). Thus, the quality of digital interaction with target audiences is becoming not merely a communication tool but also one of the decisive factors in ensuring universities' competitiveness in the education services market.

As a result of these transformations, the role of marketing in the activities of higher education institutions (HEIs) is being redefined. The traditional model, primarily focused on promoting educational programs and attracting applicants, is evolving into an integrated stakeholder engagement management system based on digital communications, data analytics, interaction personalization, digital reputation management, and the creation of long-term value in educational services.

An analysis of contemporary international research reveals a gradual shift from the study of individual digital marketing (DM) tools toward its conceptualization as a component of the strategic management of higher education institutions. The works of Dwivedi et al. (2021), Verhoef et al. (2021), Kraus et al. (2021), Krishen et al. (2021), and Shankar et al. (2022) explore the theoretical and methodological foundations of the digital transformation of marketing activities, the use of digital platforms, data analytics, and personalized communications. Research by Holmes et al. (2022) and Zawacki-Richter et al. (2024), along with analytical materials published by UNESCO (2023) and the OECD (2026, January 19), focuses on the potential of AI, Learning Analytics, and data management technologies to support managerial decision-making, personalize the educational experience, and enhance university competitiveness.

A separate strand of academic discourse focuses on digital marketing in educational services. The works of Nofrizal et al. (2024), Collins et al. (2024), Pawar (2024), and Alshurideh et al. (2025) address issues related to university digital branding and reputation, educational program positioning, factors influencing the choice of higher education institutions, communication personalization, and stakeholder engagement management.

An important contribution to the development of this research area has also been made by Ukrainian scholars. Lisun's monograph (2024) examines the conceptual foundations of DM in educational services, strategic

approaches to managing digital marketing communications, web analytics, digital positioning tools for educational institutions, and factors shaping an educational brand. Iankovets (2025) explores the strategic nature of digital marketing and substantiates the relationship between strategic assets, digital marketing tools, and customer experience design, demonstrating the need for their integrated use to create value. Certain aspects of the digital transformation of higher education institutions are addressed in the works of Kalinichenko (2022), which focus on the development of university digital infrastructure, digital competencies, and the integration of modern digital technologies into Ukraine's higher education system.

Thus, an analysis of international and Ukrainian scholarly sources reveals a gradual evolution in research approaches, from the study of individual digital tools and communication channels to the conceptualization of digital marketing as a component of strategic management aimed at creating value, managing stakeholder engagement, and ensuring university competitiveness. Despite significant advances in research on the digital transformation of education, digital ecosystems, EdTech, digital communications, Learning Analytics, data-driven management, and the application of artificial intelligence, the theoretical and methodological foundations of proactive digital marketing in educational services remain insufficiently developed. Most contemporary studies focus on individual digital marketing tools, the digitalization of the educational process, or the use of information and communication technologies in the activities of educational institutions. Meanwhile, the development of a proactive strategic stakeholder engagement management system in which AI serves as an integrator of management mechanisms has yet to receive comprehensive conceptual substantiation.

The analysis of scholarly sources made it possible to trace the evolution of marketing approaches in higher education and identify patterns in the transformation of perceptions regarding the role of digital marketing in the activities of higher education institutions. Based on a synthesis of theoretical principles, the main stages in the development of educational services marketing have been identified, reflecting its gradual transition from traditional marketing communications to strategic digital management of stakeholder engagement and the formation of a proactive digital model (*Figure 1*).

The results of the analysis of the evolution of educational services marketing indicate that each stage of its development was accompanied by the formation of corresponding scientific concepts, which successively expanded the subject area and managerial purpose of digital marketing (DM) in higher education. Their systematisation makes it possible to trace the development of scientific thought from the concept of educational services marketing to AI-driven Marketing and to substantiate the assumption that proactive digital marketing of educational services is emerging as the next stage in its evolution. In accordance with the logic of this evolution, it is appropriate to identify the main conceptual areas that reflect the gradual increasing complexity of the content, tools, and managerial functions of marketing in higher education.

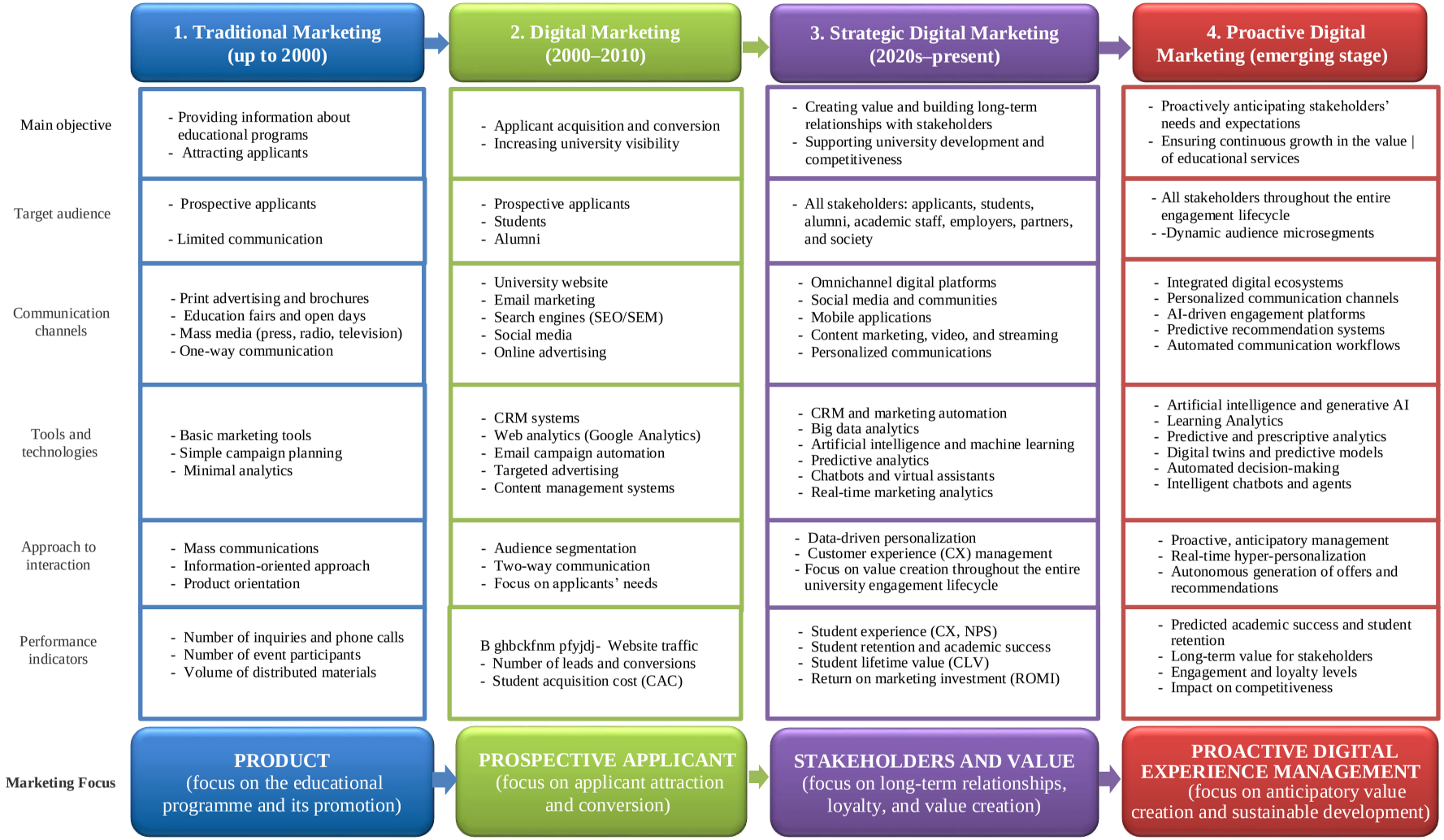


Figure 1. Evolution of educational services marketing: from the traditional to the proactive digital model

Source: compiled by the authors based on Alshurideh et al. (2025), Bohara et al. (2024), Collins et al. (2024), Dwivedi et al. (2021), Dwivedi et al. (2023), Krishen et al. (2021), Nofrizal et al. (2024), Verhoef et al. (2021), Pawar (2024), Shankar et al. (2022), Kalinichenko (2022), Lisun (2024), Iankovets (2025).

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The Concept of Educational Services Marketing

The starting conceptual area is educational services marketing, as presented in the works of Nofrizal et al. (2024), Collins et al. (2024), Pawar (2024), Lisun (2024), and other scholars. Within this area, the main focus is on university brand development, educational programme positioning, the study of factors influencing the choice of a higher education institution (HEI), digital reputation management, marketing communications, and ensuring the competitiveness of educational services.

These studies substantiate that a prospective student's decision is shaped by a set of interrelated factors, including academic reputation, the quality of educational programmes, employment prospects, the university brand, communication activity, recommendations, information accessibility, and the digital presence of the higher education institution. At the same time, scholars emphasise that, under contemporary conditions, universities compete not only in terms of educational programme quality but also in terms of the quality of digital interaction with stakeholders.

The Concept of Digital Marketing

The subsequent stage in the development of scientific thought is associated with the formation of the concept of digital marketing, which significantly broadened the traditional understanding of the scope and tools of marketing activities. In contemporary research, digital marketing is interpreted not merely as the use of digital promotion channels but as a comprehensive system of interaction with consumers that integrates digital platforms, social media, big data, marketing analytics, marketing process automation, personalised communications, and AI technologies (Dwivedi et al., 2021; Krishen et al., 2021; Verhoef et al., 2021; Shankar et al., 2022).

Unlike the traditional marketing model, digital marketing enables interactivity and two-way communication, measurable results, the prompt adjustment of marketing activities, message personalisation, customer experience management, and data-driven decision-making. The development of digital technologies has thus created the preconditions for the transition from mass marketing communications to personalised and continuous interaction with consumers.

The Concept of Digital Marketing Transformation

The widespread adoption of digital technologies and their integration into all areas of organisational activity have led to the formation of the concept of digital marketing transformation. Within this approach, digital marketing is no longer viewed as a separate functional area or a set of technological tools, but as an integral component of an organisation's systemic digital transformation.

The works of Verhoef et al. (2021), Kraus et al. (2021), Dwivedi et al. (2023), and Iankovets (2025) substantiate that digital technologies transform not only marketing tools but also business models, value creation processes, mechanisms of interaction with consumers, and approaches to strategic management. This concept centres on digital platforms, customer orientation, digital experience management, omnichannel communications, CRM systems, data integration and management, and the use of analytics to support strategic management decisions.

Thus, while the concept of digital marketing reflects the expansion of channels, technologies, and formats of interaction with consumers, the concept of digital marketing transformation involves a systemic restructuring of marketing processes, management mechanisms, and value creation models based on digital technologies.

The Concept of Digital Marketing in Higher Education Institutions

The further development of scientific thought has led to the formation of the concept of digital marketing in higher education institutions, within which the general principles of digital marketing have been adapted to the specific characteristics of university operations. Unlike commercial organisations, higher education institutions interact with various stakeholder groups: prospective applicants, students, alumni, employers, academic partners, government authorities, and members of the public. Consequently, digital marketing in higher education is increasingly regarded not merely as a system for promoting educational services but as a tool for strategically managing stakeholder relationships. This approach involves the integration of digital communications, official university websites, social media, SEO, content marketing, CRM systems, marketing automation, chatbots, digital reputation management, and analytics (Pawar, 2024; Bohara et al., 2024; Alshurideh et al., 2025; Lisun, 2024; Kalinichenko, 2022).

The Concept of Artificial Intelligence-Based Marketing

The next stage of evolution is associated with the formation of the concept of AI-based marketing, which qualitatively transforms the role of digital technologies in marketing activities. While previous concepts involved the use of digital technologies as a means of communication, automation, and support for marketing processes, AI-based marketing is grounded in the use of AI as a tool for analysis, forecasting, and support for marketing and management decisions.

The reports by UNESCO (2023) and the OECD (2026, January 19), as well as the works of Brand et al. (2026), Holmes et al. (2022), and

Zawacki-Richter et al. (2024), establish that the application of AI technologies, Learning Analytics, big data, predictive analytics, and generative artificial intelligence enables the transition from reactive to proactive management of interactions with students. These technologies make it possible to predict prospective applicants' behaviour, personalise communications, analyse users' digital footprints, evaluate the effectiveness of marketing campaigns, automate stakeholder interactions, and support data-driven management decision-making. It should be noted, however, that even within the concept of AI-based marketing, artificial intelligence is primarily regarded as a set of individual digital technologies or tools for automating marketing activities rather than as an integrated mechanism for the strategic management of stakeholder engagement (*Table 1*).

Table 1

Comparative analysis of contemporary concepts of digital marketing of educational services

Concept	Main Content	Conceptual and Research Limitations
Educational Services Marketing	University branding, positioning, factors influencing the choice of an HEI, reputation	Insufficient consideration of the impact of digital transformation, data management, and AI technologies on the marketing activities of HEIs
Digital Marketing	Digital communication channels, CRM systems, social media, web analytics, content marketing, marketing process automation	The concept is primarily oriented towards the commercial sector; insufficient consideration of the specific features of stakeholder engagement management in higher education institutions
Digital Marketing Transformation	Data-driven management, customer experience, digital platforms, omnichannel communications, transformation of marketing processes and value creation models	The main focus is on the digitalisation of business processes; the managerial mechanisms of proactive engagement with university stakeholders remain insufficiently explored
Digital Marketing in Higher Education Institutions	University branding, digital communications, educational programme positioning, digital reputation management, and stakeholder relationship management	A comprehensive conceptual approach integrating digital communications, data analytics, CRM systems, and managerial mechanisms into a system of strategic management of higher education institutions has not yet been developed
Artificial Intelligence-Based Marketing	Artificial intelligence, *Learning Analytics*, predictive analytics, chatbots	Artificial intelligence is primarily regarded as a technological tool for automation; its role as an integrator of the managerial mechanisms of proactive digital marketing of educational services has not been sufficiently substantiated

Source: compiled by the authors.

The synthesis of the results of the comparative analysis (*Table 1*) indicates that the evolution of scientific concepts reflects a gradual transition from traditional educational services marketing to the use of digital technologies, data analytics, and artificial intelligence. At the same time, the concepts examined have not yet developed a comprehensive approach to proactive digital marketing as an integrated system for the strategic management of stakeholder engagement. The mechanisms for anticipating stakeholder needs,

predicting behaviour, initiating managerial actions, continuously monitoring digital interactions, and integrating these processes into the strategic management system of HEIs remain insufficiently explored.

Thus, the current state of scientific research indicates the absence of a comprehensive concept of proactive digital marketing of educational services that would combine structural components, managerial mechanisms, digital technologies, and artificial intelligence into a unified system aimed at anticipating stakeholder needs, creating long-term value for educational services, and strengthening the competitive positions of HEIs.

In view of the above, the aim of this article is to develop the conceptual foundations of proactive digital marketing of educational services as an integrated system for the strategic management of stakeholder engagement and to substantiate the functional role of artificial intelligence as a mechanism for integrating the managerial processes involved in its implementation in HEIs.

To achieve this aim, the following objectives have been established:

- analyse the evolution of scientific approaches to the development of educational services marketing under conditions of digital transformation;
- examine global practices in the development and application of proactive digital marketing by higher education institutions;
- systematise the structural components of proactive digital marketing of educational services;
- substantiate the managerial mechanisms for its implementation in higher education institutions;
- reveal the role of artificial intelligence as an integrating mechanism of proactive digital marketing of educational services;
- identify the organisational, technological, and managerial prerequisites for implementing an AI-oriented model of proactive digital marketing (PDM) within the strategic management system of a higher education institution.

The study is based on the hypothesis that proactive digital marketing of educational services is not a collection of separate digital tools but an integrated system for managing stakeholder engagement, the effectiveness of which is ensured by the synergy of mechanisms for forecasting, personalisation, monitoring, automation, and support for managerial decision-making. Within this system, AI performs an integrative function by enabling the interconnected application of these mechanisms and facilitating the transition from a reactive digital marketing model to proactive management of the creation, promotion, and delivery of educational services.

The research methodology is based on a combination of systemic, structural-logical, comparative, and conceptual approaches to examining contemporary scholarly works and international analytical reports by the European Commission n.d., the OECD (2026, January 19), UNESCO (2023), QS (2025, June 12), and the Pew Research Center (2024, December 12). To achieve the research aim, the study employs methods of scientific generalisation and systematisation, comparative analysis, content analysis of

case studies of leading universities worldwide, conceptual modelling, and graphical visualisation of the results.

Structurally, the article consists of three sections. The first examines global practices in the development and application of proactive digital marketing by HEIs and systematises its structural components. The second section addresses the managerial dimension of PDM of educational services and identifies its key mechanisms: forecasting stakeholder needs and behaviour, personalising digital interactions, monitoring educational trajectories, automating marketing communications, and providing information and analytical support for managerial decision-making. The third section substantiates the integrative function of AI within the system of managerial mechanisms of proactive digital marketing and identifies the prerequisites for its effective implementation in the strategic management system of HEIs.

1. Global practices in the development of proactive digital marketing in higher education institutions

The digital transformation of higher education has led to changes in universities' approaches to marketing activities. Leading HEIs worldwide are gradually transitioning to a proactive digital marketing model focused not only on responding to already established demand but also on anticipating needs and predicting the behaviour of prospective applicants, personalising digital interactions, and applying AI, predictive analytics, and marketing process automation to establish long-term relationships with stakeholders. This involves not merely the use of digital communication channels, websites, and social media, but also the development of integrated digital stakeholder engagement systems whose functioning is based on the use of data, analytical technologies, automation tools, AI, and personalised communications (*Table 2*).

Table 2

Global practices in the development of proactive digital marketing in higher education institutions

Development Stage	Period	Key Characteristics	University Cases	Manifestations of Proactivity
Digitalisation of Educational Activities	2000–2010	Development of digital infrastructure, open educational resources, LMS, university websites, and online communications	Massachusetts Institute of Technology (OpenCourseWare), The Open University	Expanded access to educational services, development of a global digital audience, and growth of digital interaction
Data-Driven Stakeholder Engagement Management	2010–2020	CRM systems, Learning Analytics, marketing automation, digital analytics, and communication personalisation	Arizona State University, The Open University, University of Arizona	Forecasting educational needs, early identification of risks, and personalised interaction with prospective applicants and students

End of Table 2

Development Stage	Period	Key Characteristics	University Cases	Manifestations of Proactivity
AI-Driven Digital Marketing	Since 2020	Generative artificial intelligence, predictive analytics, digital assistants, omnichannel communications, and automated decision-making	Arizona State University, National University of Singapore, University of Michigan, Georgia State University	Predicting prospective applicants' behaviour, AI-based personalisation, automated recommendations, and data-driven decision support

Source: compiled by the authors based on (Brand et al., 2026; Boroowa & Herodotou, 2022; Georgia State University, n. d.; Hernández-de-Menéndez et al., 2022; Kukulska-Hulme et al., 2020; Massachusetts Institute of Technology, n. d.; National University of Singapore, n. d.; Renick, 2022; The Open University, n. d.).

The synthesis of the results presented in *Table 2* indicates that the features of a proactive approach can be traced back to the early stages of universities' digital transformation, when open digital learning environments and online platforms began to be used not only to disseminate learning materials but also as tools for establishing long-term relationships with a global educational audience. The subsequent development of digital technologies led to a transition towards models based on the use of CRM systems, Learning Analytics, predictive analytics, and automated communications. This made it possible to predict the behaviour of prospective applicants and students, identify their needs in a timely manner, personalise communications, and provide anticipatory support. The practices of The Open University and Arizona State University are particularly representative in this context, as both institutions have integrated digital analytics into their stakeholder relationship management systems.

The effectiveness of implementing proactive digital marketing practices is reflected not only in the expansion of universities' digital presence but also in improved student engagement, retention, and academic performance.

A compelling example in this context is the experience of Georgia State University, where the GPS Advising system, based on predictive analytics and more than 800 risk indicators, enables continuous monitoring of individual student learning trajectories, automatic identification of academic failure risks, and the initiation of personalised support measures by academic advisers. Its application has made it possible to move from a reactive student support model to proactive management of students' learning and academic development.

According to the university, the implementation of GPS Advising contributed to a 7-percentage-point increase in the four-year graduation rate, a reduction in the average time to degree completion by more than half a semester, and the delivery of over 90,000 personalised support interventions

during the past year. Thus, the use of predictive analytics has transformed digital communications from a means of providing information into a strategic tool for managing student engagement, retention, and academic performance (Renick, 2022; Georgia State University, n.d.).

The case of The Open University demonstrates another dimension of proactive digital marketing, associated with the use of Learning Analytics to manage the student experience and improve the effectiveness of interactions with students. The university employs analytical tools to predict academic difficulties at an early stage, identify students who require additional support, and personalise appropriate interventions based on digital footprints generated within the virtual learning environment. Research conducted using the Open University Learning Analytics Dataset confirms that data on student activity on digital platforms, login frequency, completion of learning assignments, and patterns of online interaction can be used to predict learning outcomes and the likelihood of successful course completion. This enables the university to move from responding to existing academic problems to proactively managing individual student learning trajectories (Boroowa & Herodotou, 2022; Kukulska-Hulme et al., 2020).

In the context of PDM, the experience of The Open University is important because it demonstrates the expansion of marketing logic beyond the applicant recruitment stage. Within this model, digital marketing encompasses the entire lifecycle of interaction with students, from generating initial interest in an educational programme to supporting academic achievement, improving student retention, fostering a positive digital experience, and creating long-term value from educational services.

The experience of Arizona State University is also noteworthy, as the university consistently integrates CRM technologies, digital services, data analytics, and personalised communications into its system of interaction with prospective applicants and students. In this case, proactivity is reflected not only in the digital support provided to students but also in the university's ability to scale its educational offerings in line with the needs of different target audience segments, including online students, working adults, international students, and individuals requiring flexible learning pathways.

The development trajectory of Arizona State University demonstrates that the integration of digital technologies into marketing and educational activities has contributed to a substantial expansion of student enrolment. Specifically, the total number of students at ASU increased from 76.7 thousand in 2013 to over 160 thousand in 2025, while the number of online students rose from approximately 10 thousand to more than 81 thousand. These figures provide grounds for viewing digital services, CRM-oriented communications, and data analytics not merely as tools for supporting the educational process but also as components of the university's

strategic expansion and the strengthening of its presence in the educational services market (Hernández-de-Menéndez et al., 2022).

The case of Arizona State University demonstrates that PDM in higher education can facilitate a transition from traditional recruitment to the management of a digital educational ecosystem, within which the university anticipates the needs of different stakeholder groups, personalises communications, expands access to educational programmes, and creates long-term value for students.

The synthesis of the results of the analysis of global practices provides grounds for asserting that the effectiveness of PDM is manifested not so much in the expansion of universities' digital presence as in improving the effectiveness of stakeholder engagement, particularly in attracting prospective applicants, retaining students, improving academic performance, and enhancing the soundness of managerial decisions. Despite differences in the digital strategies of individual universities, the results of the content analysis reveal a common logic underlying the implementation of PDM, based on the integration of data, analytical technologies, personalised communications, automation, and mechanisms for anticipatory managerial response (*Figure 2*).

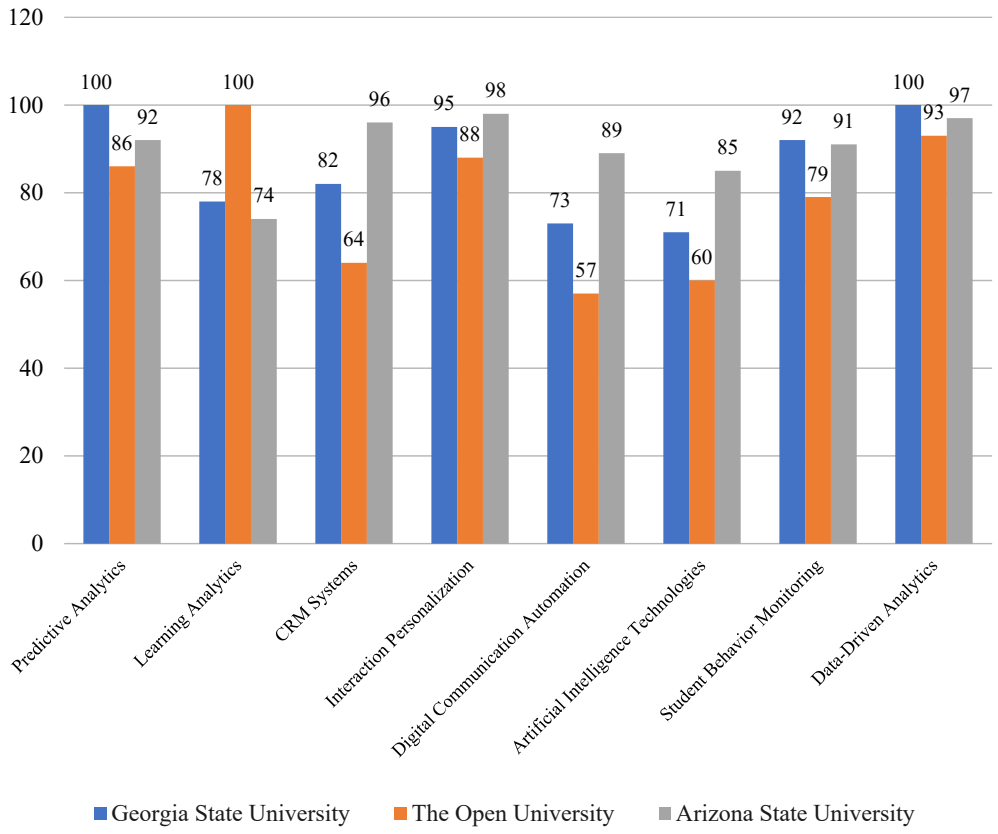


Figure 2. Results of the content analysis of proactive digital marketing tools (%)

Source: compiled by the authors based on (Arizona State University, n. d.; Boroowa & Herodotou, 2022; Georgia State University, n. d.; Hernández-de-Menéndez et al., 2022; Kukulska-Hulme et al., 2020; Renick, 2022; The Open University, 2026, June 1).

Thus, the results of the content analysis demonstrate that the defining characteristic of PDM at leading universities is not the use of individual digital technologies as such, but their integration into a comprehensive system for managing stakeholder engagement. The most widespread management mechanisms include forecasting stakeholder needs and behaviour, personalising digital interactions, data-driven management, providing information and analytical support for decision-making, and focusing on the creation of long-term value from educational services.

CRM systems, Learning Analytics, AI technologies, marketing automation, and other digital solutions serve as technological enablers for implementing these mechanisms rather than constituting independent components of proactive marketing. This provides grounds for asserting that PDM of educational services develops around a set of interrelated management mechanisms that ensure the anticipatory identification of stakeholder needs, forecasting of their behaviour, personalisation of communications, support for managerial decision-making, and the creation of long-term value. A systematisation of the common logic underlying their implementation in the practices of leading higher education institutions is presented in *Table 3*.

Table 3

Structural Components of Proactive Digital Marketing of Educational Services

Component	Content Characterisation	Practical Implementation in Higher Education Institutions
Technological	Reflects the digital foundation of proactive marketing, associated with the use of CRM systems, Learning Analytics, predictive analytics, artificial intelligence, marketing automation, digital platforms, and personalised services	Establishing a unified digital environment for engagement with prospective applicants, students, alumni, employers, and other stakeholders
Managerial	Characterises the university's ability to use data, analytics, and digital tools to forecast stakeholder needs, support managerial decision-making, and strategically develop educational services	Transitioning from reactive responses to requests to data-driven management of stakeholder engagement
Communication	Reflects a change in the nature of the university's interaction with target audiences, from mass information dissemination to personalised, omnichannel, and automated digital communications	Personalised engagement with prospective applicants and students at all stages of their educational journey
Value-oriented	Reveals the ability of proactive digital marketing to create long-term value from educational services for prospective applicants, students, alumni, employers, the university, and society	Improving recruitment effectiveness, increasing student engagement and retention, strengthening the university's digital reputation, and expanding its educational audience

Source: compiled by the authors.

The synthesis of the structural components presented provides grounds for asserting that PDM of educational services cannot be reduced to the use of a single information system or a set of digital tools. Its essence is

determined by the integration of technological, managerial, communication, and value-oriented components into a comprehensive system for the strategic management of stakeholder engagement. In this context, CRM systems, Learning Analytics, predictive analytics, marketing automation, and AI technologies provide the technological infrastructure for the functioning of this system, whereas forecasting, personalisation, monitoring, communication automation, and information and analytical support for decision-making constitute its key management mechanisms. The nature of their combination and practical implementation depends on the strategic objectives, level of digital maturity, and managerial capacity of HEIs. The identified pattern provides a theoretical basis for further substantiating the managerial dimension of PDM of educational services.

2. The managerial dimension of proactive digital marketing of educational services

Under conditions of full-scale war, population decline, and intensifying international competition in the global educational services market, the managerial dimension of PDM assumes strategic importance for ensuring the competitiveness and sustainable development of Ukraine's higher education system. One of the most serious challenges is the intensification of youth educational migration, accompanied by a decline in the number of prospective applicants, heightened competition between universities, and an increased risk of human capital loss.

According to UNESCO, in 2024, 664.6 thousand Ukrainian children and young people were integrated into formal education systems in European countries, substantially expanding the potential pool of prospective applicants to higher education institutions abroad. At the same time, even before the outbreak of the full-scale war, more than 80 thousand Ukrainian citizens were pursuing higher education at foreign universities, while the scale of academic mobility among Ukrainian youth increased significantly after 2022 (UNESCO, n. d.).

Taken together, population decline, external migration, and growing academic mobility create long-term risks to the country's human resources, scientific, and innovation potential. Under these conditions, Ukrainian HEIs compete not only with one another but also with foreign universities for prospective applicants. Consequently, PDM extends beyond the function of informational promotion of educational programmes and assumes the status of a strategic mechanism for managing the competitiveness of HEIs, enabling the forecasting of target audiences' needs and behaviour, personalisation of engagement, enhancement of the attractiveness of educational programmes, strengthening of trust in the national higher education system, and creation of conditions for curbing educational migration.

The proactive nature of digital marketing is of particular importance, as it makes it possible to move from responding to a decline in the number of prospective applicants to proactively shaping their motivation, supporting their educational trajectories, and building long-term relationships between HEIs and stakeholders. Under these conditions, the competitiveness of a modern university is increasingly determined not by the intensity of marketing communications, but by its ability to forecast the behaviour of prospective applicants, adapt its educational offerings in a timely manner, and personalise digital interactions.

In this regard, PDM should be considered not as a set of individual digital tools or communication channels, but as an integrated system for the strategic management of stakeholder engagement, aimed at the anticipatory identification of their needs, forecasting their behaviour, personalising digital interactions, automating marketing processes, and providing data-driven information and analytical support for decision-making. This approach significantly broadens the traditional interpretation of digital marketing, shifting it from the functional level of implementing marketing activities to the level of strategic management of HEI development.

From the perspective of contemporary management theory, the practical implementation of such a system is ensured by a set of interrelated management mechanisms that determine the logic of digital interaction between HEIs and stakeholders and ensure its proactive nature. Within this study, a management mechanism is interpreted as a means of exercising managerial influence that ensures the transformation of the potential of digital technologies into specific managerial actions, procedures, and strategic decisions.

Thus, identifying a system of management mechanisms makes it possible to explain the transition from a reactive model of digital marketing to a proactive one, reveal the internal logic of its functioning, and demonstrate how digital technologies are integrated into a comprehensive system of strategic management aimed at creating long-term value from educational services and ensuring the competitiveness of a higher education institution. The synthesis of theoretical principles and the results of the analysis of global practices made it possible to conceptualise a system of management mechanisms for implementing PDM of educational services. The proposed system encompasses five interrelated components: forecasting, personalisation, monitoring, automation, and support for managerial decision-making (*Figure 3*).

The proposed system conceptualises the managerial logic of PDM of educational services, within which digital technologies provide instrumental support, while the decisive factor in its effectiveness is the coordinated functioning and mutual reinforcement of management mechanisms.

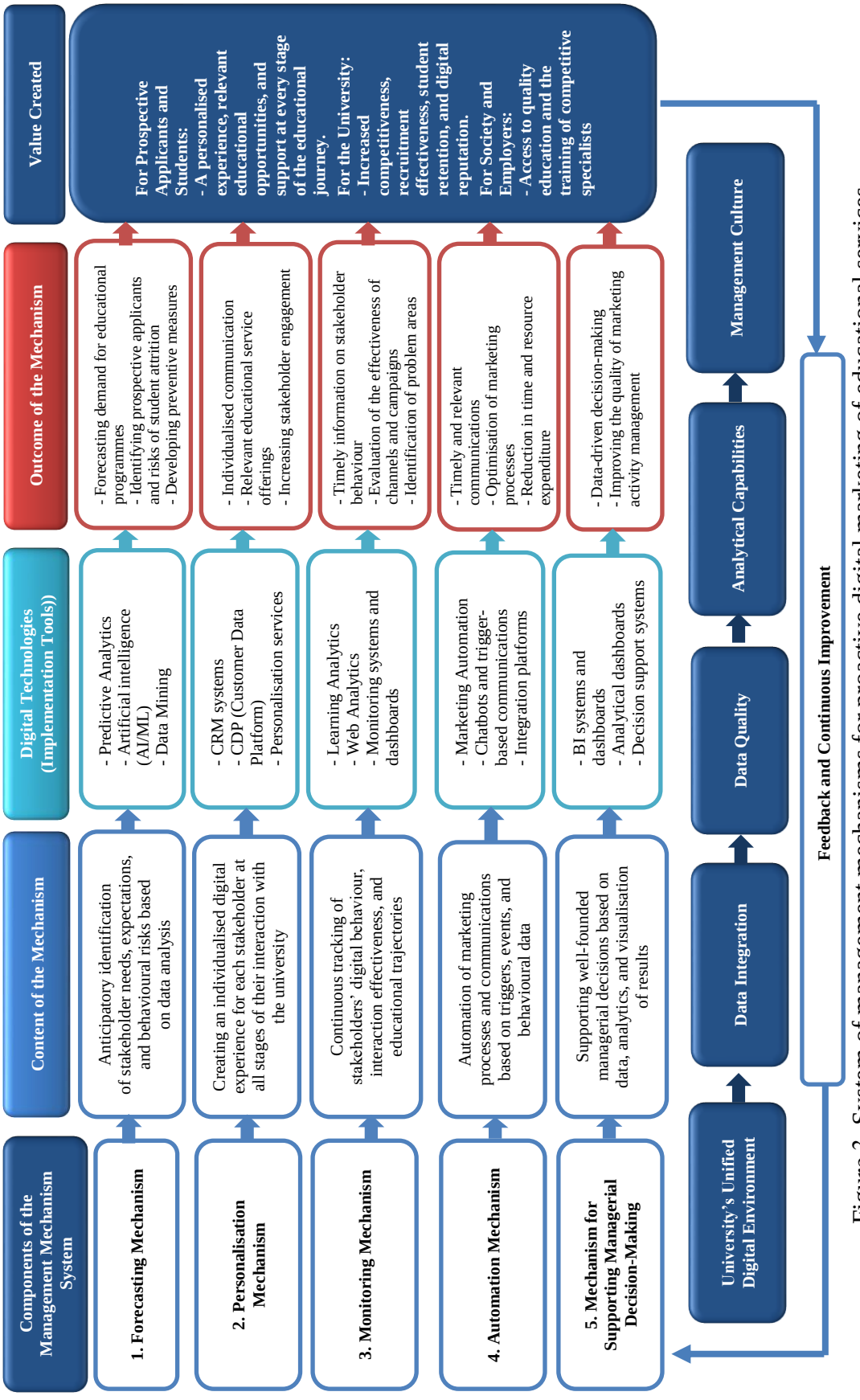


Figure 3. System of management mechanisms for proactive digital marketing of educational services

Source: compiled by the authors.

The synthesis of the research findings provides grounds for asserting that the level of development of PDM of educational services is determined not by the number of implemented digital technologies or information systems, but by the degree of integration and synergistic interaction of key management mechanisms. To conceptualise this relationship, a synergy function is proposed, reflecting the integrated impact of the coordinated interaction of key management mechanisms on the development of proactive digital marketing of educational services (1).

$$PM = F\,Sy\,(Pr,P,M,A,D)\,, \qquad (1)$$

where: PM – proactive digital marketing of educational services;
Sy – synergy function of management mechanisms;
Pr – prediction;
P – personalisation;
M – monitoring;
A – automation;
D – support for managerial decision-making.

The proposed function is conceptual in nature and is intended to provide a formalised representation of the relationship between the key management mechanisms involved in implementing PDM of educational services. The synergy function Sy characterises the degree of integration, coordination, and mutual reinforcement of the mechanisms of forecasting, personalisation, monitoring, automation, and support for managerial decision-making within a unified stakeholder engagement management system. Unlike traditional approaches, in which the effectiveness of digital marketing is associated primarily with the use of individual technological solutions, the proposed approach is based on the premise that proactivity results from the integrated and coordinated functioning of interrelated management mechanisms and cannot be achieved through the isolated application of individual digital technologies. Accordingly, an increase in the level of synergy between these mechanisms enhances HEIs' ability to anticipate stakeholder needs, personalise digital interactions, adapt to changes in the external environment in a timely manner, improve the soundness of managerial decisions, and create long-term value from educational services.

Thus, the functioning of PDM of educational services is based on the systematic transformation of data into strategic managerial decisions through the integrated interaction of the mechanisms of forecasting, personalisation, monitoring, automation, and decision-making support. The coordinated interaction of these mechanisms generates a synergistic effect that contributes to enhancing the competitiveness of HEIs, strengthening their digital reputation, increasing student engagement and retention, and creating conditions for reducing the scale of educational migration among Ukrainian youth.

3. Artificial intelligence as an integrator of management mechanisms for proactive digital marketing

The analysis of global practices and the substantiation of PDM management mechanisms have demonstrated that their practical implementation requires not only the use of digital communication channels, CRM systems, and web analytics tools, but also the development of a technological foundation capable of integrating diverse datasets, forecasting stakeholder behaviour, personalising digital interactions, automating marketing processes, and supporting managerial decision-making in near real time.

In this context, AI assumes particular importance and should be considered not merely as a tool for digitalising individual marketing processes, but as an integration technology that ensures the coordinated functioning of PDM management mechanisms.

Unlike traditional digital tools, which are primarily designed for collecting, storing, transmitting, and visualising information, AI technologies are capable of combining analytical, predictive, recommendation, communication, and automation functions. As a result, within the system of proactive digital marketing of educational services, AI emerges not as a separate technological tool, but as a system-wide integrator of the mechanisms of forecasting, personalisation, monitoring, automation, and support for managerial decision-making within a unified management cycle (*Figure 4*).

Unlike traditional digital technologies, which are primarily focused on supporting individual marketing functions, artificial intelligence establishes an end-to-end integration of data and management mechanisms, transforming a set of disparate digital processes into a comprehensive system for the strategic management of stakeholder engagement.

In the proposed model, artificial intelligence serves as a central integrator that accumulates and combines data from CRM and ERP systems, LMS, web analytics tools, social media, and other digital platforms; processes and analyses this data comprehensively; identifies patterns; and establishes an information and analytical basis for forecasting, personalisation, monitoring, automation, and support for managerial decision-making. In this way, artificial intelligence technologies facilitate the coordinated functioning of these mechanisms within a unified management cycle and enhance the proactive nature of digital interaction between HEIs and stakeholders.

Thus, artificial intelligence emerges not as a separate element of the PDM system, but as its integrating component, ensuring the practical implementation of the synergy function of management mechanisms substantiated in the previous section of the study. Through AI technologies, the interaction between the mechanisms of forecasting, personalisation, monitoring, automation, and decision-making support acquires a systemic character, creating the conditions for developing a proactive model of stakeholder engagement management.

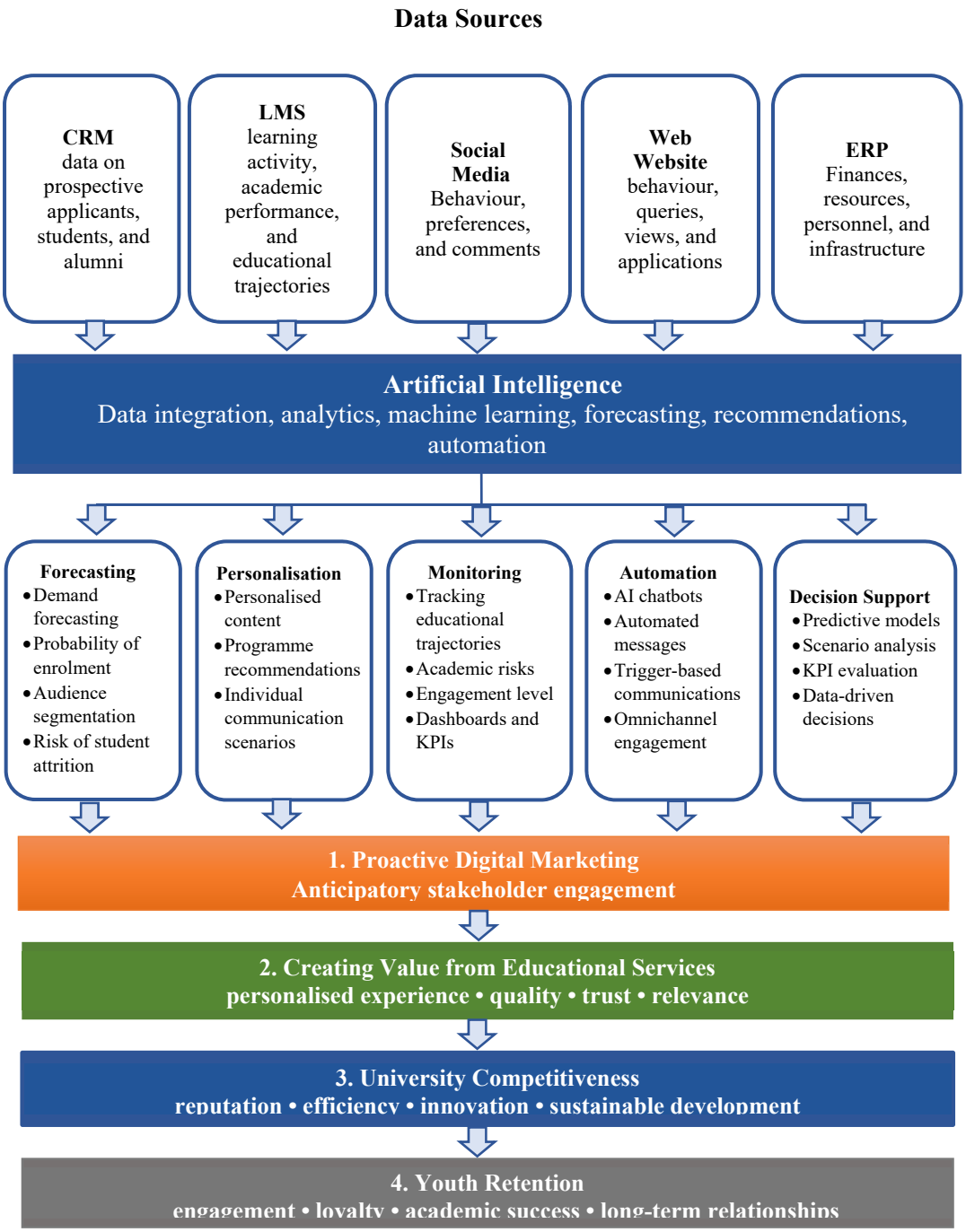


Figure 4. Conceptual model of the integration of data sources and management mechanisms for artificial intelligence-based proactive digital marketing

Source: compiled by the authors.

At the same time, the use of artificial intelligence as an integrator of PDM management mechanisms entails a number of risks and limitations. The effectiveness of its application is determined not only by the level of technological advancement of the relevant solutions, but primarily by the conditions under which they are incorporated into the strategic management

system of HEIs. An analysis of the practices of leading universities demonstrates that even a high level of digitalisation does not guarantee a transition to PDM in the absence of an integrated information environment, adequate data quality, algorithmic transparency, a well-developed digital culture among staff, effective data governance, and robust mechanisms for ethical oversight.

Therefore, the implementation of AI is not a sufficient condition for establishing the proactive nature of digital marketing. A transition to a proactive model becomes possible only through the systematic integration of artificial intelligence technologies into the strategic management of HEIs, where they ensure the synchronisation of management mechanisms, provide information and analytical support, and facilitate their coordinated functioning. For this reason, particular importance should be attached to identifying the prerequisites for the effective implementation of AI technologies in the system of proactive digital marketing of educational services, as summarised in *Table 4*.

Table 4

Organisational and managerial prerequisites for the effective implementation of artificial intelligence in the proactive digital marketing system

Prerequisite	Management Conditions for Implementation	Expected Strategic Outcome
Integrated Data	Establishing a unified university information environment by integrating CRM, LMS, ERP, web analytics, and digital communication channels	Improving the completeness of analytical coverage and the validity of forecasting
Data Quality	Ensuring the reliability, relevance, standardisation, and continuous updating of data	Increasing the accuracy of AI-based analytical results
Integration of Information Systems	Organising automated data exchange between the digital platforms of the higher education institution	Ensuring continuity of digital interaction and consistency of information flows
Algorithmic Transparency	Using explainable artificial intelligence models and ensuring that the recommendations generated can be interpreted	Increasing stakeholder trust in managerial decisions
Digital Competencies of Staff	Developing staff readiness to use AI analytics and make data-driven decisions	Improving the effectiveness of management activities
Ethical Data Governance	Adhering to the principles of digital ethics, confidentiality, security, and responsible data use	Strengthening the social responsibility of the higher education institution

Source: compiled by the authors.

The synthesis of the organisational and managerial prerequisites for the effective implementation of artificial intelligence presented in *Table 4* provides grounds for asserting that the effectiveness of its application within the PDM system is determined not so much by the level of technological sophistication of individual digital solutions as by the degree to which an organisational and managerial environment capable of ensuring their systematic integration and coordinated functioning has been established. To formalise this relationship, an artificial intelligence integration function is proposed:

$$I_{AI}=F(ID,DQ,IS,EX,DC,EG,H), \quad (2)$$

where: I_{AI} – the level of artificial intelligence integration into the proactive digital marketing system, characterising its capacity to ensure the coordinated functioning of the relevant management mechanisms;

ID – Integrated Data;
DQ – Data Quality;
IS – Information Systems Integration;
EX – Explainability;
DC – Digital Competence;
EG – Ethical Governance;
H – Human-Centred Management.

The integration function characterises the capacity of a higher education institution to use artificial intelligence as an integrator of PDM management mechanisms. Unlike existing approaches, it reflects not the level of development of individual AI technologies, but the degree to which the organisational and managerial conditions necessary for their systematic integration into the strategic management of a higher education institution have been established. Each component of the function is a necessary, but not sufficient, condition for the effective implementation of AI. Only their comprehensive interaction makes it possible to realise its integration function, which is manifested in the synchronisation of the mechanisms of forecasting, personalisation, monitoring, automation, and support for managerial decision-making.

Thus, the proposed artificial intelligence integration function provides the conceptual foundation for implementing the synergy function of management mechanisms presented in *Formula (1)*. While the synergy function reflects the outcome of the coordinated functioning of the mechanisms of forecasting, personalisation, monitoring, automation, and support for managerial decision-making, the integration function reveals the organisational and technological means of achieving this outcome through the use of AI. The relationship between these functions can be formalised as follows:

$$Sy=F(I_{AI}), \quad (3)$$

where: *Sy* – the synergistic outcome of the coordinated functioning of PDM management mechanisms;
I_{AI} – the level of AI integration into the PDM system;
F – a functional relationship reflecting the influence of the level of AI integration on the formation of synergy among management mechanisms;
AI – the AI integration function.

The integration function characterises the capacity of artificial intelligence to ensure the interconnection and synchronisation of individual management mechanisms, whereas the synergy function reflects the outcome of their coordinated functioning in the form of established proactivity in digital marketing. Thus, integration is a prerequisite for achieving a synergistic outcome, while synergy is a necessary condition for the development of PDM of educational services.

The proposed integration function has not only conceptual but also practical significance, as it provides a methodological basis for developing an integral index to assess the capacity of HEIs to integrate AI technologies into the proactive digital marketing system. Operationalising its components makes it possible to move from a conceptual description to a quantitative assessment of the university's level of organisational and digital readiness, conduct comparative analyses of higher education institutions, identify critical areas of digital transformation, and evaluate the effectiveness of AI implementation in the strategic management system.

At the same time, AI's considerable integration potential is not a sufficient condition for improving the effectiveness of marketing activities at HEIs. The effectiveness of its use is determined not only by the technological capabilities of individual digital solutions, but primarily by the degree to which the organisational and managerial environment has been developed, the quality of data, the integration of information systems, the digital competencies of staff, algorithmic transparency, adherence to ethical principles, and the preservation of the human-centred nature of strategic management.

Thus, the results of the study provide grounds for viewing artificial intelligence not as a standalone digital tool, but as a systemic integrator of the management mechanisms of proactive digital marketing of educational services. The proposed integration function complements the synergy function and, together with it, forms a comprehensive conceptual model in which the level of AI integration explains how management mechanisms function in a coordinated manner, while the synergistic outcome reflects the result of their comprehensive interaction. This approach characterises the transition from the fragmented use of digital technologies to the development of an intelligent, proactive, data-driven system for the strategic management of stakeholder engagement, aimed at creating long-term value in educational services, enhancing the competitiveness of higher education institutions, and strengthening Ukraine's human capital.

It should be noted that the implementation of PDM in Ukrainian higher education institutions must take into account the specific characteristics of educational systems operating under martial law. Forced internal and external migration, the geographical dispersal of higher education students, unequal access to digital infrastructure, and the limited financial resources of universities constrain the comprehensive integration of CRM systems, data analytics, and AI technologies. At the same time, these very conditions reinforce the importance of a proactive engagement model capable of enabling the early identification of student attrition risks, the personalisation of digital communications, and the maintenance of continuous interaction with students regardless of their location. This necessitates the phased implementation of the proposed model in accordance with the level of digital maturity, resource capacity, and strategic priorities of each individual HEI.

Conclusions

The study provides grounds for asserting that the current stage of digital marketing development in higher education is characterised by a transition from the use of individual digital technologies and communication channels to the formation of a proactive, integrated, data-driven system for the strategic management of stakeholder engagement. The hypothesis put forward has been confirmed by the sequence of results obtained: a comparative analysis of scientific concepts made it possible to identify the limitations of a fragmented technological approach to digital marketing; a content analysis of the practices of leading universities revealed a common rationale for combining forecasting, personalisation, monitoring, automation, and information and analytical support for managerial decision-making; conceptual modelling made it possible to formalise the relationships between these mechanisms through the synergy function, while the artificial intelligence integration function revealed the mechanism for ensuring their coordinated functioning within a unified management cycle. Taken together, these results confirm that the effectiveness of proactive digital marketing is determined not by the scale of digitalisation as such, but by the level of integration and synergy among interrelated management mechanisms, with artificial intelligence acting as their systemic integrator.

The study proposes a conceptual approach to interpreting proactive digital marketing of educational services as a system for the strategic management of stakeholder engagement based on the anticipatory identification of stakeholders' needs, behavioural forecasting, personalisation of digital interactions, automation of marketing processes, and data-driven support for managerial decision-making. Unlike existing scientific approaches, in which digital marketing is primarily considered through the lens of individual technologies or marketing tools, the proposed concept substantiates its managerial nature and reveals the mechanism of transition from a reactive to a proactive model of higher education institution functioning.

The scientific novelty of the study lies in substantiating a system of interrelated management mechanisms for proactive digital marketing, encompassing forecasting, personalisation, monitoring, automation, and support for managerial decision-making, and developing two interrelated conceptual functions. *The first*, the synergy function, explains the patterns governing the coordinated functioning of management mechanisms; *the second*, the integration function, elucidates the role of artificial intelligence as an integrator of these mechanisms and establishes a conceptual relationship between the organisational and managerial prerequisites for AI implementation and the synergistic outcome of the proactive digital marketing system.

The practical significance of the proposed approach lies in its potential use as a methodological basis for developing digital marketing strategies for higher education institutions, assessing their level of digital maturity and artificial

intelligence integration capacity, and substantiating managerial decisions concerning the digital transformation of universities. The proposed synergy and integration functions provide a theoretical and methodological foundation for developing an integral index to assess higher education institutions' readiness to implement an AI-oriented proactive digital marketing model and for conducting comparative studies across universities.

Prospects for further research include developing a methodology for the quantitative assessment of artificial intelligence integration capacity based on the proposed integration function; constructing an integral index of proactive digital marketing for higher education institutions; testing it on a sample of Ukrainian and international universities; empirically examining the impact of the level of proactive digital marketing on the competitiveness of higher education institutions, student recruitment and retention, international attractiveness, and the reduction of educational migration risks.

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MARKETING STRATEGIES IN TOURISM-LED REAL ESTATE SALES AND DEVELOPMENT: CASE OF GEORGIA

This article examines the impact of tourism marketing strategies on real estate sales and development in Georgia. It argues that destination marketing influences property markets indirectly but systematically by producing destination awareness, place familiarity, repeat visitation, perceived safety, year-round utility, and confidence in the future attractiveness of a location. The study is based on the hypothesis that these marketing-induced effects positively influence tourism-related real estate demand and development, although their strength depends on urban, institutional, and market conditions. These mechanisms can transform a temporary visitor into a repeat tourist, a market observer, a mixed-motive user, and eventually a buyer or partial resident. The hypothesis is examined through a structured review of high-impact tourism, urban economics, housing, and regional-development research, combined with secondary analysis of official Georgian statistics and sectoral market evidence for 2019–2025, with particular attention to Batumi. The analysis applies comparative, trend-based, and case-study approaches to identify the principal mechanisms linking tourism marketing with property-market outcomes. The study introduces two original analytical tools: a tourist-to-buyer conversion ladder and a bidirectional tourism-real estate transmission matrix. The findings indicate that branding, digital

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МАРКЕТИНГОВІ СТРАТЕГІЇ У СФЕРІ ДЕВЕЛОПМЕНТУ ТУРИСТИЧНОЇ НЕРУХОМОСТІ: КЕЙС ГРУЗІЇ

У статті досліджено вплив маркетингових стратегій у сфері туризму на продаж і розвиток нерухомості в Грузії. Обґрунтовано, що маркетинг туристичних дестинацій опосередковано, але систематично впливає на ринки нерухомості через формування обізнаності про дестинацію, місцевість, стимулювання повторних відвідувань, відчуття безпеки, можливості використання об'єктів упродовж усього року та впевненості в майбутній привабливості певної локації. Дослідження ґрунтується на гіпотезі, що ці ефекти, зумовлені під впливом маркетингової діяльності, попиту і розвитку нерухомості, пов'язану з туризмом, хоча сила такого впливу залежить від міських, інституційних і ринкових умов. Завдяки цим механізмам тимчасовий відвідувач може перетворитися на туриста, який повертається, спостерігача за ринком, користувача з кількома цілями перебування, а згодом – покупця або особу, яка частково проживає в цій місцевості. Гіпотезу перевірено за допомогою структурованого огляду провідних наукових досліджень у сферах туризму, міської економіки, житлової нерухомості та регіонального розвитку, а також вторинного аналізу офіційної статистики Грузії й галузевих ринкових даних за 2019–2025 рр. з особливою увагою до Батумі. Для визначення основних механізмів взаємозв'язку між туристичним маркетингом і результатами функціонування ринку нерухомості застосовано порівняльний, трендовий та метод дослідження окремого випадку. У дослідженні запропоновано два оригінальні аналітичні

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reputation, de-seasonalization, events, accessibility communication, and segment-specific marketing can increase the perceived use value and income potential of property. However, positive spillovers are conditional on construction quality, urban planning, institutional credibility, housing affordability, and consistency between promoted image and lived experience. The article concludes that tourism strategy, investment policy, housing-market monitoring, and municipal planning should be coordinated through an integrated governance framework for sustainable destination and property-market development nationally.

Keywords: tourism marketing strategy, destination branding, real estate sales, tourism-led development, visitor-to-buyer conversion, short-term rentals, second homes, Batumi; Georgia.

інструменти: модель послідовного перетворення туриста на покупця та матрицю двосторонньої взаємодії між туризмом і нерухомістю. Результати дослідження свідчать, що брендинг, цифрова репутація, подолання сезонності, проведення заходів, інформування про транспортну доступність і маркетинг, орієнтований на конкретні сегменти, можуть підвищувати сприйману споживчу цінність нерухомості та її потенціал генерування доходу. Водночас позитивні побічні ефекти залежать від якості будівництва, міського планування, інституційної довіри, доступності житла за ціною та відповідності між сформованим рекламним образом і реальним досвідом перебування в певній місцевості. Зроблено висновок, що туристична стратегія, інвестиційна політика, моніторинг ринку житла та муніципальне планування мають бути скоординовані в межах інтегрованої системи управління, спрямованої на сталий розвиток туристичних дестинацій і ринку нерухомості на національному рівні.

Ключові слова: маркетингова стратегія у сфері туризму, брендинг туристичних дестинацій, продаж нерухомості, розвиток під впливом туризму, перетворення відвідувача на покупця, короткострокова оренда, друге житло, Батумі, Грузія.

JEL Classification: M31; Z33; R31; R58; L83.

Introduction

Tourism marketing is normally evaluated through indicators such as destination awareness, arrivals, overnight stays, expenditure, conversion rates, and brand sentiment. Yet successful destination communication also affects markets outside the formal tourism sector. It can alter how non-residents evaluate neighborhoods, coastal zones, resort corridors, and mixed-use developments; it can increase the perceived utility of owning or repeatedly using property in a destination; and it can influence developer expectations concerning future demand. The central proposition of this article is therefore that marketing strategies have a measurable, although mediated, influence on tourism-led real estate sales and development.

The mechanism is not equivalent to direct property advertising. Destination organizations rarely promote apartments, villas, or branded residences. Their influence operates at an earlier and more fundamental stage of decision-making. By communicating accessibility, safety, lifestyle, culture, environmental quality, and year-round experiences, destination marketing creates a cognitive and emotional frame within which later investment decisions become plausible. Meta-analytical tourism research shows that destination image strongly shapes behavioral intentions and loyalty, while urban-economic research demonstrates that tourism intensity and short-term rental activity may become capitalized into residential rents and prices (Afshardoost & Eshaghi, 2020; García-López et al., 2020; Mikulić et al., 2021).

Recent studies reinforce this connection from a broader spatial and investment perspective. Yang et al. (2024) show that second-home tourism can contribute to the emergence of distinct urban tourism enclaves and reshape the socio-spatial structure of destinations, while Rainer and Steiner (2025) demonstrate how tourism demand, short-term accommodation, external investment, and real-estate financialization may become mutually reinforcing within tourism-intensive locations. These findings extend earlier work on destination image, housing prices, and short-term rentals, but they still leave insufficiently explained the intermediate process through which destination marketing itself may influence property consideration and development decisions. This unresolved mechanism is particularly relevant in emerging destinations where tourism promotion, foreign visitation, residential construction, and investment narratives evolve simultaneously.

Georgia offers a particularly revealing case. During the pre-pandemic decade, the country expanded international connectivity, strengthened digital promotion, diversified source markets, and increased the visibility of Tbilisi, Batumi, mountain resorts, wine regions, and heritage destinations. At the same time, residential and mixed-use construction intensified, especially in Tbilisi and Batumi. The COVID-19 shock interrupted tourism income and exposed the vulnerability of visitor-dependent property models, while the subsequent recovery restored demand, expenditure, and investor interest. The co-movement does not prove that tourism is the only cause of property-market change, but it makes the transmission mechanisms analytically important.

Batumi concentrates these dynamics. It combines a strong leisure image, an established summer season, growing shoulder-season activity, sea-view and central-city price premiums, substantial apartment construction, foreign-buyer participation, and the widespread use of residential units as short-term accommodation. It is therefore an appropriate location for examining how public destination communication, private project marketing, platform visibility, and investor expectations interact. At the same time, Batumi illustrates the risks of unbalanced growth: seasonality, congestion, uneven construction quality, pressure on long-term rental supply, and the possibility that speculative narratives may outrun actual use value.

The research problem can be stated precisely: existing tourism studies explain how image, satisfaction, experience, and electronic word of mouth affect visitation and loyalty, whereas housing and urban-economic studies explain how tourism and short-term rentals affect rents, prices, and neighborhood change. Less attention has been given to the connecting process through which destination marketing contributes to property consideration and development decisions, particularly in small emerging economies. The article addresses this gap by joining the two literatures and applying them to the Georgian context.

The purpose of the article is to develop an explanatory framework that identifies the behavioural, market, and spatial mechanisms through which tourism marketing strategies influence tourism-related real estate demand and development in Georgia, with particular attention to Batumi, and to determine the conditions under which these effects support sustainable

destination development. The study proceeds from the hypothesis that tourism marketing has an indirect but systematic positive effect on tourism-related property demand through destination awareness, repeated visitation, place familiarity, perceived safety, year-round utility, and confidence in the future attractiveness of the destination, while the strength of this effect depends on accessibility, urban quality, institutional credibility, construction standards, housing affordability, and wider market conditions. The hypothesis is assessed through a structured synthesis of recent peer-reviewed research and secondary analysis of Georgian tourism and real estate evidence for 2019–2025. The analytical sequence first identifies theoretically established transmission mechanisms, then compares them with observable Georgian indicators and the Batumi case, and finally evaluates whether the available evidence supports, qualifies, or limits the proposed relationships. The study relies on triangulation between peer-reviewed literature, official statistics, and market reports; its principal limitation is that aggregate secondary data cannot establish buyer-level causality or isolate destination marketing from other macroeconomic and property-market determinants.

The study asks four research questions: (RQ1) Through which mechanisms do tourism marketing strategies influence real estate consideration, sales, and development? (RQ2) How does the visitor experience evolve into a tourist-to-buyer conversion process? (RQ3) How do tourism recovery, destination image, and property-market expansion interact in Georgia and Batumi? (RQ4) Which governance arrangements can maximize positive investment spillovers while limiting affordability, spatial, and reputational risks? Consistent with this logic, Section 2 develops the conceptual foundations of the tourism–real estate relationship, Section 3 explains the research design and analytical framework, Section 4 examines Georgia's post-pandemic tourism–property dynamics, Sections 5 and 6 assess marketing transmission, crisis effects, and governance implications, and Sections 7 and 8 synthesize the findings, conclusions, recommendations, limitations, and directions for further research.

1. Literature review and conceptual foundations

1.1. Destination image, loyalty, and extended forms of place consumption

Destination image is commonly understood as a combination of cognitive beliefs, affective evaluations, and an overall mental representation of place. Cognitive image concerns attributes such as accessibility, infrastructure, prices, safety, climate, and attractions; affective image concerns feelings such as excitement, comfort, prestige, or attachment. Afshardoost and Eshaghi's (2020) meta-analysis of 87 studies demonstrates that image is a significant predictor of tourist behavioral intentions, with affective and overall image showing particularly strong relationships. Zhang et al. (2014) similarly find that destination image contributes to loyalty through satisfaction and perceived value.

These findings matter for real estate because buying property abroad is not only a financial calculation. It is a high-involvement form of place consumption. The prospective buyer evaluates whether the destination is understandable, emotionally attractive, accessible, safe, and likely to retain its appeal. Marketing therefore reduces the psychological distance between the consumer and the place. A destination that is repeatedly encountered through coherent campaigns, favorable media coverage, user-generated content, and personal visits becomes cognitively easier to evaluate and emotionally easier to trust.

Familiarity is a critical intermediary. First-time visitors rely heavily on generalized destination cues. Repeat visitors acquire more granular knowledge of districts, transport, seasonality, service standards, and everyday costs. This experience lowers information asymmetry and allows the consumer to compare ownership with repeated accommodation expenditure. Past experience also increases resilience of image during crises, because familiar visitors can distinguish temporary shocks from the destination's long-run qualities (Rasoolimanesh et al., 2021).

1.2. Tourism intensity, housing prices, and affordability

Urban and regional research provides evidence that tourism can be capitalized into housing markets. Mikulić et al. (2021), using Croatian municipal data, show that tourism activity affects housing affordability and that the consequences depend on accommodation intensity, seasonality, and local vulnerability. Cró and Martins (2024) report that tourism activity can influence house-price dynamics in tourism-dependent countries. These studies establish that visitor economies affect not only hospitality revenues but also the cost and distribution of residential space.

Short-term rental platforms create a direct conversion mechanism by allowing residential property to generate tourism income. García-López et al. (2020) find that Airbnb expansion in Barcelona contributed to increases in rents and transaction prices, particularly in areas with high platform activity. Koster et al. (2021) use regulatory discontinuities in Los Angeles County and show that restrictions reduced listings and produced measurable housing-price effects. Franco and Santos (2021) identify positive effects of Airbnb intensity on Portuguese residential values and rents. Together, these studies show that expected tourism revenue can be embedded in property prices.

The literature therefore supports a dual interpretation. Tourism can stimulate regeneration, construction, and neighborhood investment, but it can also intensify rent gaps, displacement pressures, and platform concentration. Xu M. and Xu Y. (2021) show that home-sharing may affect neighborhood investment, illustrating that the built environment can improve alongside affordability pressures. For policy, the relevant question is not whether tourism affects housing, but under which regulatory and spatial conditions benefits exceed social costs.

1.3. Second homes, mobility, and hybrid consumers

Second-home research complicates the conventional distinction between tourist and resident. Hannonen et al. (2024) argue that the pandemic renewed interest in second-home mobilities, flexible residence, and the changing relationship between work, leisure, and place. An owner may spend several weeks or months in a destination, work remotely, host relatives, rent the property during absence, and purchase local services repeatedly. This person is neither a conventional tourist nor a permanent resident.

The hybrid consumer combines experiential, financial, and mobility motives. Experiential motives include climate, scenery, gastronomy, culture, social networks, and personal attachment. Financial motives include expected appreciation, rental yield, currency diversification, and portfolio strategy. Mobility motives include visa rules, air connectivity, travel time, and the capacity to use the property flexibly. The relative weight of these motives changes across the consumer journey.

For Georgia, the hybrid-consumer perspective is more useful than a binary tourist-versus-investor model. A foreign buyer may first discover Georgia through leisure travel, later purchase for mixed personal and rental use, and continue generating tourism expenditure after acquisition. Conversely, an investor who has never visited may be attracted by developer marketing but remain dependent on destination-level reputation. Both pathways demonstrate that tourism and property demand share information channels and place-based expectations.

1.4. Real estate development as part of the tourism product

Real estate is not merely a passive recipient of tourism demand. New projects can expand accommodation-like capacity, create leisure and retail clusters, improve public space, and alter the visual identity of a destination. Serviced apartments and branded residences combine residential ownership with hotel-type management. Mixed-use developments integrate lodging, food, entertainment, offices, wellness, and retail. These formats influence length of stay, expenditure distribution, and the spatial concentration of visitors.

Well-designed projects can reinforce a destination brand by adding architecture, pedestrian environments, conference facilities, cultural venues, and reliable services. Poorly integrated projects can produce congestion, shadowing, infrastructure pressure, fragmented public space, or visual inconsistency. The marketing spillover is consequently reciprocal: a strong destination image supports project sales, while completed projects either validate or damage the image.

2. Research design and analytical framework

2.1. Method, scope, and evidence selection

The study uses a structured conceptual synthesis combined with descriptive case analysis. The literature review prioritizes peer-reviewed research from high-impact journals in tourism management, urban economics, regional

science, housing, marketing, and tourism geography. Sources were selected where they provide a clearly identifiable mechanism relevant to destination image, loyalty, short-term rentals, housing prices, second homes, platformization, or crisis transmission.

The Georgian evidence covers the period from 2019 to 2025, with occasional reference to early 2026 releases that report full-year 2025 results. Official data are drawn from the National Statistics Office of Georgia, the National Bank of Georgia, the Georgian National Tourism Administration, UN Tourism, and published market reports. The analysis distinguishes visitors, visits, tourist-type visits, receipts, expenditure, business turnover, investment flows, apartment transactions, prices, rents, and yields. These indicators are not interchangeable and are interpreted according to their official definitions.

The design is intentionally non-causal. A national or city-level increase in tourism and property transactions does not prove that marketing caused the increase. Real estate is also influenced by interest rates, migration, exchange rates, construction costs, household income, geopolitical conditions, regulation, and investor sentiment. The study therefore uses process tracing: it identifies theoretically supported channels, checks whether Georgian evidence is consistent with those channels, and specifies mediating conditions.

The tourist-to-buyer conversion ladder conceptualizes the gradual transition from destination awareness and first-time visitation to property consideration, acquisition, and repeated post-purchase use. It reflects the assumption that real estate demand in tourism-oriented destinations may emerge through successive stages of familiarity, experience, perceived utility, and investment evaluation rather than through a single purchase decision. The stages of this process and the dominant decision problem associated with each stage are presented in *Table 1*.

Table 1

Tourist-to-buyer conversion stages in tourism-led real estate demand in Georgia, 2019–2025

Stage	Dominant behavior and decision problem
1. Destination-aware audience	Recognizes Georgia or Batumi through paid, earned, shared, or owned media; has no immediate property intention
2. First-time experiential visitor	Tests the promoted promise through actual travel and forms initial judgments about safety, service, accessibility, and value
3. Attached repeat visitor	Returns, develops place familiarity, compares seasons and neighborhoods, and begins to imagine longer use
4. Property-aware observer	Monitors prices, projects, rents, legal conditions, and management options without a final commitment
5. Yield-sensitive hybrid user	Combines lifestyle utility with expected rental income, capital appreciation, or portfolio diversification
6. Buyer or second-home owner	Acquires property for personal use, rental use, or a mixed strategy
7. Partial resident and destination advocate	Returns repeatedly, hosts others, consumes local services, and may generate positive or negative word of mouth

Source: developed by the author based on (Afshardoost and Eshaghi, 2020; Hannonen et al., 2024; Yang et al., 2024), and the analytical framework of this study.

The ladder explains why destination marketing may influence real estate without explicitly promoting investment. Different stages require different information. Awareness campaigns matter at the beginning; service quality and authenticity matter during visits; transparent market information matters during observation; legal clarity, management standards, and financing matter near purchase. A failure at any stage can stop conversion.

The model is probabilistic rather than deterministic. Most visitors will never buy property, and many buyers may enter through networks or investment promotion rather than tourism. Nevertheless, the ladder identifies measurable transition indicators: repeat-visit rate, property-search behavior, requests for legal information, intention to stay longer, inquiries about management services, purchase conversion, and post-purchase visitation.

The bidirectional tourism–real estate transmission matrix is designed to show how tourism and property-market dynamics interact across the principal domains of demand, pricing, development, reputation, and crisis transmission. The framework emphasizes that the relationship operates in both directions: tourism and destination marketing can influence property demand, value expectations, and development feasibility, while real estate expansion can reshape accommodation capacity, visitor experience, urban quality, and destination resilience. The main transmission channels and the mediating conditions that determine their strength are summarized in *Table 2*.

Table 2

Bidirectional tourism–real estate transmission mechanisms in Georgia, 2019–2025

Domain	Tourism/marketing → real estate	Real estate → tourism	Key mediators
Demand	Awareness, repeat visitation, lifestyle aspiration, and investor confidence increase property consideration	New units create accommodation supply and attract owner-visitors	Income, air access, visa regime, legal simplicity, trust
Pricing	Destination attractiveness and expected visitor income create locational and yield premiums	Higher land and housing costs affect hotel feasibility, labor, and visitor prices	Seasonality, platform regulation, interest rates, exchange rate
Development	Year-round campaigns and events improve feasibility expectations for mixed-use and serviced projects	Projects add services, public realm, venues, and spatial concentration	Planning quality, infrastructure, construction standards
Reputation	Positive experience and eWOM reduce perceived destination and investment risk	Completed projects validate or undermine the promoted image	Delivery quality, reviews, consumer protection
Crisis	Travel shocks reduce occupancy, yields, sales, and project finance	Property distress, unfinished construction, or rent inflation damage destination quality	Reserves, diversification, regulation, coordinated response

Source: developed by the author based on (Mikulić et al., 2021; García-López et al., 2020; Hannonen et al., 2024; Rainer and Steiner, 2025), and the analytical framework of this study.

To make the link between the research questions, the evidence used in the analysis, and the corresponding directions for empirical verification explicit, *Table 3* provides a research-question and evidence map. It complements the analytical framework by showing how each research question is connected to the principal evidence discussed in the article and to a suitable approach for subsequent empirical testing (*Table 3*).

Table 3

Research questions and evidence map

Research question	Principal evidence	Suggested empirical test
RQ1: Marketing mechanisms	Image, eWOM, seasonality, events, segmentation, accessibility	Structural-equation model linking image and experience to property consideration
RQ2: Conversion process	Tourist-to-buyer ladder	Visitor and buyer surveys; transition probabilities; longitudinal tracking
RQ3: Georgia and Batumi	Official tourism data, market reports, spatial indicators	District-level panel models; difference-in-differences where policy changes permit
RQ4: Governance	Affordability, planning, consumer protection, crisis monitoring	Dashboard evaluation and comparative policy analysis

2.2. Suggested empirical model

A future quantitative study can define property consideration, purchase intention, actual purchase, or owner-visit frequency as dependent variables. Explanatory variables may include cognitive destination image, affective image, repeat visitation, satisfaction, perceived safety, accessibility, year-round utility, expected rental potential, institutional confidence, and digital word of mouth. Controls should include age, income, nationality, prior foreign-property ownership, exchange-rate exposure, financing access, and travel motivation.

A parsimonious specification is: Property consideration = f(destination image, repeat experience, accessibility, perceived safety, year-round utility, expected rental potential, institutional confidence, and individual controls). The effect of marketing should be treated as mediated by experience and moderated by institutional trust. A multi-group model can compare first-time visitors, repeat visitors, property observers, buyers, and owners.

For spatial analysis, district-level apartment prices and rents can be related to tourism intensity, platform listings, distance to attractions, public-space improvements, and major events, with fixed effects and appropriate controls. Where a clear regulatory or infrastructure intervention exists, quasi-experimental designs should be preferred to simple correlations.

3. Georgia's post-pandemic tourism-real estate dynamics

3.1. Tourism collapse, recovery, and renewed confidence

In 2019 Georgia recorded more than USD 3.2 billion in international travel receipts, confirming tourism's importance for foreign-exchange earnings and service-sector activity. The pandemic then produced an exceptional discontinuity. Border restrictions and mobility collapse reduced

receipts to roughly USD 0 54 billion in 2020. The shock affected hotels, restaurants, transport, guides, attractions, and informal suppliers, but it also removed the income base of apartments and developments that depended on short-term visitors.

The property effect was transmitted through expectations. Existing owners faced lower occupancy and weaker rent, while prospective buyers revised yield assumptions. Developers confronted uncertainty about foreign demand, construction schedules, and project finance. Even where nominal prices did not immediately fall, the risk premium increased. The episode demonstrated that tourism-linked property is exposed not only to housing-market cycles but also to mobility shocks.

The recovery restored the core conditions for tourism-related property demand. Geostat reported 5.8 million international visitors in 2025, 7% more than in 2024, and 5.5 million tourist-type visits. International visitors made 6.9 million visits and generated approximately GEL 15.0 billion in expenditure, with average expenditure of about GEL 2 187 per visit. Leisure remained the largest purpose, and Tbilisi and Adjara were the most visited territorial units (Geostat, 2026a).

3.2. Business activity, investment, and real estate expansion

Business statistics show synchronized expansion in visitor-facing services and real estate activities after the shock. Turnover in hotels and restaurants increased strongly during the recovery period, while real estate activities also expanded. Co-movement is consistent with a common recovery in consumption, construction, and investment, although it does not isolate a single causal direction.

Foreign direct investment adds another dimension. Real estate has remained a visible recipient of foreign capital in Georgia, while hospitality investment is sometimes embedded in the same projects through hotels, serviced apartments, branded residences, or mixed-use complexes. UN Tourism's investment guidance for Georgia emphasizes the country's tourism assets and investment potential, demonstrating how tourism narratives and capital-attraction narratives are institutionally connected.

3.3. Batumi as a concentrated tourism-property system

Batumi is the clearest Georgian example of tourism-led real estate formation. Its sea-front location, walkable central areas, subtropical identity, architecture, events, and proximity to mountain Ajara create a differentiated destination proposition. These attributes are repeatedly used in public destination promotion and private project marketing. The city consequently functions both as a tourism destination and as a transnational property product.

Market reports show high transaction volumes, substantial new supply, and visible foreign-buyer participation. Galt & Taggart reported 3 670 registered apartment transactions in the second quarter of 2024 with a market value of approximately USD 229.7 million and an indicative rental

yield near 9.4%. In the second quarter of 2025, sales reached 4 018 units; reported primary- and secondary-market prices and standard-apartment rents also increased. The figures should be treated as market-report estimates rather than official causal evidence, but they confirm the scale of tourism-facing property activity.

At the same time, Batumi is affected by variables beyond tourism. Migration after 2022, regional capital movements, exchange-rate conditions, construction costs, interest rates, and geopolitical risk influenced rents and transactions. A rigorous account must therefore describe tourism as a major reinforcing factor, not an exclusive explanation. The strength of the tourism channel varies by district, project type, buyer segment, and season.

3.4. Comparative evidence and lessons for Georgia

International cases provide useful analogies but should not be copied mechanically. Barcelona demonstrates how high platform intensity in dense central districts can raise rents and prices and provoke strong regulation. Lisbon and other Portuguese cities show how tourism demand, foreign investment, and short-term rentals can interact in heritage areas. Croatian coastal municipalities demonstrate the importance of seasonality and housing affordability. Los Angeles County shows that regulation can produce measurable market effects. These cases identify mechanisms, not predetermined outcomes for Georgia.

4. The impact of marketing strategies on real estate sales and development

4.1. Destination branding as a value-creation mechanism

Destination branding creates a coherent promise about what a place offers and why it is distinctive. For tourism-led real estate, the promise influences value through three routes. First, it increases awareness and reduces search costs. Second, it attaches symbolic meaning to location, such as coastal lifestyle, cultural authenticity, safety, prestige, or creative energy. Third, it creates expectations about future demand, which can be translated into occupancy and resale assumptions.

A strong brand does not automatically raise every property value. Capitalization is selective. The effect is likely to be strongest in locations and projects that embody the promoted attributes. If Batumi is communicated as a walkable sea-and-city destination, properties near the boulevard and active urban areas benefit more than disconnected projects. If Ajara is positioned as a four-season sea-and-mountain region, developments with real access to year-round experiences gain greater credibility than projects relying only on generic imagery.

Brand consistency is crucial. The visitor compares promoted image with actual experience. Clean public space, mobility, service, architecture, events, and environmental conditions either confirm or contradict the campaign. When experience confirms communication, satisfaction and

positive word of mouth reinforce both destination and property confidence. When the gap is large, marketing can accelerate reputational damage because expectations have been raised.

4.2. Digital marketing, electronic word of mouth, and investor search

Digital communication compresses the distance between tourism discovery and property search. A user can encounter a destination video, compare flights, examine neighborhoods through maps, read reviews, view construction progress, estimate short-term rental prices, and contact a broker within the same information environment. This convergence makes destination and property marketing mutually visible even when they are produced by different organizations.

Electronic word of mouth has special importance because it is interpreted as experience-based evidence. Ratings, photographs, comments, and creator content can validate claims about cleanliness, service, safety, views, walkability, and atmosphere. Lee et al. (2023) show that tourist experiences can modify destination image, emphasizing that image is dynamic rather than fixed. For property buyers, this means that post-visit digital evidence continues to influence evaluation after travel.

An effective strategy separates inspiration from verification. Inspirational content generates interest; official portals provide accurate information on seasons, access, events, and destination services; property actors provide project documents, management contracts, fees, and realistic performance scenarios. When these layers are transparent, digital marketing reduces uncertainty. When they are blurred, consumers may interpret public destination credibility as a guarantee of private return.

4.3. De-seasonalization and the perceived profitability of property

Seasonality is one of the most important channels linking marketing strategy to property feasibility. A unit that can be rented only during a short summer peak carries higher vacancy risk than a unit located in a destination with business, cultural, sports, gastronomic, educational, wellness, and remote-work demand throughout the year. De-seasonalization campaigns therefore affect not only monthly visitor distribution but also expected annual property utilization.

The mechanism operates through risk perception. Stable shoulder-season demand reduces dependence on a few weeks of peak pricing, supports permanent employment, and improves the viability of year-round services. Buyers and lenders can form more credible cash-flow assumptions. Developers can justify amenities and management systems designed for continuous operation rather than seasonal closure.

For Batumi, a four-season strategy should combine indoor and outdoor products. Conferences and business events support weekdays and cooler months; cultural programming and gastronomy support city breaks; sports and wellness create thematic demand; mountain Ajara adds nature, rural tourism, and winter possibilities; educational and remote-work products

increase longer stays. Marketing must be matched by schedules, transport, operating hours, and weather-resilient infrastructure.

4.4. MICE, events, and urban investment signalling

Meetings, incentives, conferences, exhibitions, festivals, and sports events can influence real estate through both direct demand and signalling. Directly, they generate room nights, food expenditure, transport use, and demand for flexible accommodation. Indirectly, they communicate that a city has venues, organizational capacity, connectivity, safety, and an active calendar. These attributes matter to investors evaluating year-round use.

Events expose new audiences to the destination. A business visitor may not have selected Batumi for leisure but can become familiar with the city through a conference. Delegates often belong to income and professional segments with greater capacity for property acquisition or business investment. The event therefore acts as a high-information trial visit.

The policy boundary remains important: destination authorities should promote the city's event capacity and ensure service quality, while individual projects must substantiate claims about event-driven occupancy. Public event branding should not be used as an implicit guarantee of private investment performance.

4.5. Segmentation and conversion-oriented marketing

Generic destination marketing assumes that all visitors respond to the same value proposition. Conversion-oriented strategy recognizes that different segments have different pathways toward longer use and ownership. Segmenting only by country is insufficient; motivation, life stage, travel frequency, digital behavior, and desired use pattern are equally important.

Repeat family visitors may value safety, healthcare, schools, parks, walkability, and larger units. Remote professionals may prioritize internet quality, workspaces, international access, flexible stays, and community. Lifestyle buyers may focus on climate, gastronomy, views, culture, and personal attachment. Yield-sensitive investors prioritize transparent occupancy evidence, management fees, regulation, liquidity, and resale demand. Retirees may emphasize healthcare, accessibility, quiet neighborhoods, and long-term legal certainty.

Each segment requires different content and different proof. Emotional destination storytelling is effective at awareness stage, but later conversion requires practical evidence. A repeat visitor evaluating ownership needs neighborhood information, year-round service availability, legal guidance, and realistic cost estimates. Segment-specific information reduces friction without making speculative promises.

4.6. Alignment between destination and developer marketing

The strongest positive spillover occurs when destination-level communication and project-level delivery are aligned but institutionally distinct. Destination organizations promote the territory; developers explain

the specific product. Alignment means that projects reflect the destination's credible strengths through design, services, location, and management rather than merely copying campaign imagery.

A virtuous cycle is possible. Public marketing reduces place-level uncertainty and attracts visitors. Good projects convert part of that demand into longer stays and ownership. Owners and guests generate expenditure and positive reviews. New services improve the destination. The strengthened destination brand then supports future investment. Each stage depends on actual performance.

A vicious cycle is also possible. Aggressive sales advertising may overstate guaranteed returns, use unrealistic occupancy assumptions, or present incomplete projects as extensions of the official destination brand. If units are poorly managed or infrastructure is inadequate, owners become dissatisfied, online reputation deteriorates, and unfinished or low-occupancy buildings weaken urban quality. The damage then returns to tourism demand.

Governance should therefore require accuracy in developer advertising, disclosure of fees and assumptions, escrow or completion protections where appropriate, transparent management contracts, and building-maintenance standards. These measures do not restrict legitimate marketing; they protect the credibility of the entire tourism-property system.

5. Crisis transmission, social risk, and integrated governance

5.1. How shocks move between tourism and real estate

Crisis transmission is the clearest test of interdependence. A pandemic, border closure, airline withdrawal, geopolitical escalation, natural hazard, or severe reputation event can reduce arrivals and occupancy within weeks. Tourism-linked apartments then experience lower income, buyers delay decisions, resale liquidity declines, and developers face weaker pre-sales. If projects depend on continuous sales for construction finance, the shock can affect completion.

The reverse channel is equally important. A property crisis can produce unfinished buildings, reduced maintenance, bankrupt management companies, litigation, and visible urban deterioration. These outcomes weaken destination image and visitor satisfaction. Rapid rent inflation can also raise labor costs and displace workers from central areas, reducing service quality in tourism businesses.

Shocks are amplified by concentration. Dependence on one source market, one season, one airline, one project type, or one rental platform creates common exposure. Diversification of markets and use formats is therefore not only a tourism objective but also a property-risk strategy. Projects capable of serving residents, long-stay visitors, and short-stay tourists are more resilient than units designed around a single optimistic scenario.

5.2. Affordability, carrying capacity, and resident welfare

Tourism-led real estate growth creates benefits only when resident welfare remains part of destination competitiveness. Housing affordability is

not external to tourism. Workers in accommodation, food service, transport, culture, retail, and maintenance need access to suitable housing. If wages do not keep pace with rents, labor shortages, commuting burdens, turnover, and service deterioration follow.

Carrying capacity should therefore include residential and infrastructure indicators. Visitor numbers alone cannot show whether growth is sustainable. District-level monitoring should include rent-to-income ratios, long-term rental availability, seasonal vacancy, platform density, water and wastewater capacity, traffic, public-space pressure, waste, school and healthcare demand, and resident attitudes.

Affordability policy should be proportionate to evidence. Possible tools include registration of short-term rentals, differentiated taxation, primary-residence exemptions, enforcement against illegal conversion, zoning in high-pressure districts, incentives for long-term rental, and requirements for workforce or affordable housing in large developments. The correct instrument depends on local market conditions.

5.3. An integrated governance model for Georgia

Georgia's institutional structure separates tourism promotion, municipal planning, construction regulation, statistics, finance, taxation, and consumer protection. Administrative separation is normal, but analytical separation is costly. A cross-sector governance model should create shared indicators and regular coordination without merging institutional mandates.

Consumer-protection institutions should address misleading yield claims, unclear management fees, delayed completion, and contractual imbalance. Transparent standards would strengthen rather than weaken the investment market by reducing adverse selection. Buyers who understand risks are less likely to become sources of reputational conflict.

A practical coordination mechanism could be an annual Tourism and Real Estate Sustainability Dashboard for Tbilisi, Batumi, and major resorts. The dashboard would combine tourism demand, accommodation supply, platform activity, apartment transactions, rents, construction pipeline, infrastructure pressure, resident sentiment, and consumer complaints. Public reporting would improve both policy accountability and investor decision quality.

6. Discussion

The analysis answers the title question by showing that marketing strategies influence tourism-led real estate through a sequence of mediated effects rather than a single direct causal link. Branding increases awareness and symbolic value; experience and electronic word of mouth reduce uncertainty; repeat visitation creates familiarity and attachment; de-seasonalization improves expectations of annual use; events signal urban vitality; segmentation delivers relevant information; and accurate alignment with developer communication facilitates conversion. These mechanisms affect both buyer demand and developer feasibility calculations.

For Batumi, the framework explains why sea-front image, events, digital visibility, and four-season positioning matter to real estate. They shape expectations about use and rental demand. Yet the same framework shows why promotion cannot substitute for urban quality. Infrastructure, construction standards, transparent management, and affordability determine whether marketing spillovers remain positive.

The principal theoretical limitation is that the article uses secondary evidence and process-based reasoning rather than micro-level causal estimation. The mechanisms are supported by international literature and consistent with Georgian trends, but their exact magnitude in Georgia remains unknown. The next research stage should therefore test the ladder using visitor, buyer, and owner surveys and link responses to transaction and neighborhood data.

7. Conclusions and recommendations

Tourism marketing strategies influence real estate sales and development in Georgia by shaping the perceived attractiveness, familiarity, accessibility, year-round utility, and future demand of destinations. Their effect is strongest in tourism-oriented locations and property formats where personal use and visitor income are combined. Batumi is the clearest example because the destination brand, residential construction, short-term accommodation, foreign demand, and lifestyle consumption are spatially concentrated.

The relationship is bidirectional. Tourism supplies attention, visitors, expenditure, rental demand, and locational prestige. Real estate supplies accommodation-like capacity, amenities, venues, services, and visible urban form. Each sector can strengthen the other, but each can also transmit crisis and reputational damage. This is why an integrated analytical and governance approach is necessary.

The stated purpose of the article is therefore achieved through the development of an explanatory framework that identifies the main behavioural, market, and spatial mechanisms connecting tourism marketing with tourism-led real estate demand and development in Georgia. With regard to the first research question, the analysis shows that destination branding, digital reputation, repeat visitation, de-seasonalization, events, accessibility communication, and segment-specific marketing influence property consideration by reducing uncertainty and increasing perceived use and income potential. In response to the second question, the tourist-to-buyer ladder demonstrates that the transition from visitor to buyer is gradual and may pass through repeated visitation, place familiarity, property observation, and mixed personal-investment motivation. The third question is answered by the Georgian and Batumi evidence, which indicates that tourism recovery, destination visibility, short-term accommodation demand, and real estate expansion interact positively but are also shaped by migration, interest rates, construction costs, exchange-rate conditions, and geopolitical risk. The fourth question is addressed through the proposed governance approach, which requires coordination between destination marketing, housing-market

monitoring, urban planning, consumer protection, and investment policy.

The hypothesis that tourism marketing strategies exert an indirect but systematic positive influence on tourism-related real estate demand and development is supported in a conditional rather than absolute form. The evidence is consistent with the proposed transmission mechanisms, but the strength of the relationship depends on accessibility, urban quality, construction standards, institutional credibility, housing affordability, financing conditions, and broader market dynamics. Because the study relies on secondary evidence and process-based reasoning rather than buyer-level causal estimation, the findings support the hypothesis conceptually and empirically without claiming that destination marketing alone determines property transactions.

Five recommendations follow. First, Georgia should build district-level tourism-housing data systems, including platform activity, long-term rental supply, construction pipeline, foreign ownership, and seasonal occupancy. Second, destination marketing should emphasize verifiable year-round value and avoid language that can be appropriated as an implicit guarantee of investment return. Third, consumer protection and project transparency should be strengthened for tourism-oriented real estate. Fourth, municipal planning should connect development permissions to infrastructure, public space, affordability, and management capacity. Fifth, market diversification and de-seasonalization should be treated as resilience policies for both tourism and property.

The two analytical tools proposed in the article can guide implementation. The tourist-to-buyer ladder identifies where information, experience, and institutions affect conversion. The transmission matrix tests each policy across demand, price, development, reputation, and crisis domains. Together, they transform a broad claim of interdependence into a set of observable mechanisms.

Future research should test the tourist-to-buyer conversion process using buyer- and visitor-level data and estimate how destination-image dimensions, repeat visitation, seasonality, and institutional confidence affect property consideration and purchase. Longitudinal and spatial analysis could further determine where tourism visibility is capitalized into rents and prices and where affordability effects are strongest.

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FMCG BRANDS IN THE EXPERIENCE ECONOMY: THE DIGITAL DIMENSION

This article examines the transformation of FMCG brands in the digital environment within the context of the emerging experience economy. It argues that digitalisation shapes the customer experience before physical interaction with the consumer takes place and gives it an immersive character, while competition between brands shifts towards emotional experiences, trust and social interaction. The role of retail brands in building social capital and fostering the population's subjective well-being is explored. The study is based on the hypothesis that developing an immersive customer experience for FMCG brands in the digital environment within the experience economy, implementing sustainable development principles and using digital technologies in marketing programmes increase consumer trust, emotional engagement and loyalty, thereby enhancing brand competitiveness. The methodological framework comprises a systems approach, analysis and synthesis, comparative analysis, content analysis of brand communications, structural and logical analysis, and empirical analysis of marketing programmes. The study analyses the development of an

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FMCG-БРЕНДИ В ЕКОНОМІЦІ ВРАЖЕНЬ: ЦИФРОВИЙ ВИМІР

Досліджено особливості трансформації FMCG брендів у цифровому середовищі в умовах становлення економіки вражень. Обґрунтовано, що під впливом цифровізації клієнтський досвід формується до фізичного контакту зі споживачем і набуває імерсійного характеру, а конкуренція між брендами зміщується у площину емоційних вражень, довіри та соціальної взаємодії. Розкрито роль брендів роздрібної торгівлі як суб'єктів формування соціального капіталу та суб'єктивного благополуччя населення. Дослідження ґрунтується на гіпотезі, що формування імерсійного клієнтського досвіду FMCG брендів у цифровому середовищі в економіці вражень, реалізація принципів сталого розвитку та використання цифрових технологій в маркетингових програмах підвищує рівень довіри, емоційної залученості й лояльності споживачів та, відповідно, конкурентоспроможності брендів. Методологічною базою є системний підхід, методи аналізу і синтезу, порівняльного, контент-аналізу бренд-комунікацій, структурно-логічного та емпіричного аналізу маркетингових програм. У ході дослідження проаналізовано формування

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immersive customer experience for FMCG brands, examines their brand architecture, positioning and social responsibility, and systematises digital marketing programmes according to the 4Cs framework, while outlining the specific features of omnichannel interaction with consumers. The findings indicate that integrating the experience economy, sustainable development principles and digital technologies contributes to increased consumer trust, empathy and loyalty.

Keywords: FMCG brands, experience economy, digital marketing, immersive customer experience, brand architecture, sustainable development, social responsibility, branding, brand management, omnichannel communications, retail, supermarket chains.

імерсійного клієнтського досвіду FMCG брендів, розкрито особливості їх бренд-архітектури, позиціонування та соціальної відповідальності, а також узагальнено цифрові маркетингові програми за інструментами 4C і специфіку омніканальної взаємодії зі споживачами. Встановлено, що інтеграція економіки вражень, принципів сталого розвитку та цифрових технологій сприяє підвищенню довіри, емпатії та лояльності споживачів.

Ключові слова: FMCG-бренди, економіка вражень, цифровий маркетинг, імерсійний клієнтський досвід, бренд-архітектура, сталий розвиток, соціальна відповідальність, брендинг, бренд-менеджмент, омніканальні комунікації, роздрібна торгівля, мережі супермаркетів.

JEL Classification: M31, O33, L81, I31.

Introduction

The current stage of digital economic development is characterised by a transformation in patterns of interaction between brands and consumers, particularly in the FMCG sector. The widespread adoption of digital technologies is changing the logic of consumer behaviour: the customer experience is shaped through digital marketing communication channels before consumers physically visit a store. Under these conditions, competition between brands shifts from product attributes towards emotional experiences, in line with the concept of the experience economy.

Socio-economic challenges and declining levels of subjective well-being among the population reinforce the role of retail brands in building trust, facilitating social interaction and creating positive emotional experiences. This necessitates a reconsideration of approaches to FMCG brand management based on human-centredness, empathy and inclusivity.

Recent research and publications indicate growing interest among international and Ukrainian scholars in the transformation of FMCG brands in the digital environment, the development of the experience economy and omnichannel interaction with consumers. Contemporary studies view digital marketing as a tool for shaping emotional customer experiences and building consumer trust and loyalty. Naveen Kumar and Janani (2025) examine the influence of customer experience on consumer loyalty to FMCG brands, while Sharmila and Bibiyana (2026), Karthikeyan and Prashanth (2026), and Arya (2026) focus on the role of omnichannel approaches, augmented reality (AR) and artificial intelligence (AI) technologies in developing immersive customer experiences and fostering consumer emotional engagement. Publications by Ukrainian scholars address the adaptation of brand strategies and marketing communications to the digital economy and changing consumer behaviour in the FMCG sector. In particular, Penkova et al. (2024),

Chmil and Striuk (2025), and Nazarchuk and Kovalchuk (2025) examine communication personalisation, the resilience of marketing strategies and the role of the emotional dimension of a brand in building consumer trust.

Despite the substantial body of scholarly work, the development of an immersive customer experience for FMCG brands in the digital environment remains insufficiently explored in the context of the experience economy, social interaction and omnichannel marketing communications.

The aim of this article is to synthesise the key characteristics of developing an immersive customer experience for FMCG brands in the digital environment based on the concept of the experience economy. Achieving this aim involves the following main objectives: to investigate the development of an immersive customer experience for FMCG brands in the digital environment in the context of the experience economy and social interaction; to analyse the brand architecture, positioning and social responsibility of the supermarket chains under study as elements of customer experience development; and to synthesise the key features of digital marketing programmes used by FMCG brands and their omnichannel interaction with consumers.

The study is based on the hypothesis that developing an immersive customer experience for FMCG brands in the digital environment within the experience economy, implementing sustainable development principles and using digital technologies in marketing programmes increase consumer trust, emotional engagement and loyalty, thereby enhancing brand competitiveness.

The study employs a systems approach, comparative analysis, analysis and synthesis, content analysis of brand communications, generalisation, and structural and logical analysis and empirical analysis of FMCG brands' marketing programmes. The information base comprises scholarly works by international and Ukrainian researchers in marketing and branding; data from analytics services (Serpstat); findings from international studies (the World Happiness Report, drawing on Gallup data); statistical and marketing data on retail development in Ukraine from the Ukrainian Retail Association (RAU) and other sources; and data from official and management reports, websites and publicly available materials of the FMCG brands under study.

The first section of the main body examines the development of an immersive customer experience for FMCG brands in the digital environment amid the emergence of the experience economy and the growing role of social interaction. It explores the brand architecture, positioning and social responsibility of the supermarket chains under study as elements that shape the customer experience and build consumer trust. The second section systematises FMCG brands' digital marketing programmes according to the 4Cs framework and identifies the specific features of their omnichannel interaction with consumers in the digital environment.

1. Developing an immersive customer experience for FMCG brands in the digital environment

The adoption and development of digital technologies have transformed the customer experience of FMCG brands in retail, as consumers learn about store offerings through websites, mobile applications, social media and other channels before visiting. To attract new customers and retain existing ones amid intensifying competition, stores now need to become retail and entertainment "experience destinations", combining product presentation with excellent service in which employees welcome customers as guests (Bailey & Milligan, 2020, p. 182). This approach is particularly important in Ukraine, given the large number of people experiencing unhappiness. Demonstrating care by providing positive experiences therefore becomes a key factor in stores' success.

According to the World Happiness Report, an annual global happiness ranking based on data from the US polling organisation Gallup, Ukraine ranked 111th out of 147 countries in 2025 (Gallup©, 2025). This represents a decline of 19 places compared with 2023 and six places compared with 2024. In Ukraine, as in other Central and Eastern European countries, older people are less happy than younger people. Declining quality of life and well-being contribute to an increase in dementia cases. According to World Health Organization estimates, the global population aged 65 and over will double by 2050, with the number of people living with dementia projected to reach 139 million. Improving well-being is a significant factor in dementia prevention, contributing to better cognitive health among older people. Addressing this strategic challenge requires coordinated efforts through public policy, community action and business engagement. Stores, as "experience destinations", can contribute to improving the population's overall well-being by taking guests' ages into account, fostering social engagement and providing appropriate experiences and positive emotions within a digital space that encompasses, among other dimensions, physical space and sociocultural relations. This puts into practice the principle of inclusivity in the digital economy as a prerequisite for the emergence of the experience economy.

Following the COVID-19 pandemic, increased benevolence has been observed, particularly among Millennials and Generation Z. Social interaction and social support contribute to greater happiness. Brand marketing programmes, particularly in retail, should therefore consider intergenerational interaction among guests, among employees, and between guests and employees. Applying the concept of experience design (Iankovets, 2025, pp. 311–316) also contributes to happiness and improved well-being, supporting brand development and helping to address social problems.

The theme chosen for the World Happiness Report 2025 was caring and sharing (World Happiness Report, 2024). Benevolence, empathy and trust are identified as key factors influencing happiness today (World Happiness Report, 2025). The development of social values and social

interaction worldwide remains central to sustainable development, whose principles are actively implemented by leading brands, including those in retail.

To identify the factors shaping the customer experience of FMCG brands through benevolence, empathy and trust that contribute to customer happiness, five of the strongest FMCG brands in retail were selected. These are supermarket chains whose principal economic activity falls under code 47.11: Retail sale in non-specialised stores with food, beverages or tobacco predominating. The selection was based on competitor websites identified in the digital environment by the Serpstat analytics service. The benchmark was silpo.ua, representing a supermarket chain that explicitly endorses and consistently applies the principles of the experience economy for its customers.

1.1. Brand architecture and positioning of FMCG supermarket chains

The supermarket chains' activities were analysed in terms of positioning, the emotional dimension, key success factors, the implementation of experience economy and sustainable development principles, and marketing programmes in the digital environment (Young & Rubicam Inc., n.d.; Bailey & Milligan, 2020; Robertson, 2022; Robertson, n. d.; Penkova et al., 2024; Marketing Media Review, 2025; Naveen Kumar & Janani, 2025; Nazarchuk & Kovalchuk, 2025; Chmil & Stryuk, 2025; Iankovets, 2025; Sharmila & Bibiyana, 2026; Karthikeyan & Prashanth, 2026; Arya, 2026). The mission, vision, values and positioning of the supermarket chain brands under study are presented in *Table 1*.

At the end of 2025, ATB was Ukraine's largest supermarket chain by number of stores (1.319) and net revenue (UAH 247.384.831 thousand). It is owned by ATB-Market LLC, which is part of the ATB Corporation (Financial indicators of LLC "ATB-MARKET", n. d.). ATB's key success factors are its extensive store network and broad product range, which enable it to compete effectively on price. More recently, the chain's rational positioning as "Ukraine's largest, dynamically growing retail chain" has been complemented by the emotional message "Your favourite store, your favourite brand, your favourite products". This indicates a move towards empathy and trust through the implementation of experience economy principles (Website of LLC "ATB-Market", n. d.).

ATB's closest competitor in terms of sales is the Silpo supermarket chain (Silpo-Food LLC, part of the Fozzy Group trading and industrial group). While ATB positions itself as a discounter, Silpo focuses on a "guest-centred" customer experience and emotional experiences (BrandVoice, 2023; Website of LLC "Silpo-Food", n. d.), which constitute the brand's key success factor. Over 15 years, the chain has brought disparate supermarkets together under a unified brand format, with a mission to create joy and make guests happy. Consequently, its Net Promoter Score (NPS), regularly measured by the Guest Experience Department, consistently exceeds 50, indicating strong customer loyalty.

The distinctive "Vlasnyi Rakhunok" loyalty programme, which combines consumer rewards with an effective research and marketing tool, provided the basis for management's decision to develop a data platform that would enable personalised offers at individually tailored prices for guests. Furthermore, the brand's concept of creating designer supermarkets in different styles is unique worldwide, with more than 100 such stores to date.

For a long time, the "Novus" brand, owned by Novus Ukraine LLC, was characterised by a rational approach to positioning, as reflected in its stated Mission and Values (n. d.). Convenience, accessibility and usefulness are prioritised. The brand's positioning reflects the national characteristics associated with its principal investor, the Lithuanian holding company BT Invest: rationality, seriousness, practicality and technological sophistication. These are manifested in the application of European quality standards and a transparent and responsible approach to business. The brand is well known and recognisable, but until recently it lacked the emotional dimension needed to build lasting positive associations and an immersive customer experience, which directly contribute to expanding its loyal audience and bringing the brand closer to lovemark status.

Today, the brand complements its slogan "Worthy of Your Trust" with "We Do It Because We Love It", echoing "Silpo", which regards "Novus" as its main competitor in the upper-middle price segment (Share Ua Potential, n. d.). "Silpo" regularly expresses its love for guests (SilpoLovesYou), employees and even competitors. One example was its campaign ahead of Valentine's Day in 2021, featuring personalised slogans on billboards near competitors' stores: "ATB, We Love You", "Novus, You Energise Us", "Fora, Our Love for You Goes Without Saying", "Varus, You Put Wind in Our Sails", and others (24|TV channel Kyiv, 2021). Such expressions of humanity attract attention, create emotional experiences and foster positive associations and feelings.

Over the past two years, "Novus" brand communications have become more emotional, open and "warm", reflecting a shift in positioning: "…to be even more convenient and closer to you", "We Believe Good Deeds Change the World!", "At Novus, We Believe in the Power of Dreams", and "Our Magic Is Creating Quality Products You Fall in Love With", among others. Customer orientation is becoming the foundation of the corporate culture at "Novus" (Osijek, 2025; Website of Novus Ukraine LLC, n. d.).

The "Fora" brand (Fora LLC, part of Fozzy Group) positions itself as "a chain of modern grocery stores close to home that continues to improve and grow, offering a balanced product range and optimal value for money". Overall, the rational positioning elements of "balance" and "optimal value" demonstrate an honest approach to customer relations, while the emotional dimension of "close to home" evokes associations with proximity and trust. The brand's positioning is further complemented by the emotional message "Care in Action", which was reinforced through the rebranding of "Fora" in summer 2024 (RAU, 2024). The brand's key success factor is its distinctive approach to opening welcoming, easily accessible stores in every neighbourhood, in locations where people can shop conveniently and comfortably (Website of LLC "FORA", n. d.).

Table 1

Mission, vision, values and positioning of the supermarket chain brands under study

Supermarket chains	Mission	Vision	Values	Positioning
ATB	Providing Ukraine's population with quality food products and essential non-food goods at the lowest prices	Creating a comprehensive "ATB" ecosystem for customers, encompassing all modern services and technologies: from fintech projects, loyalty programmes and online shopping to co-branding projects with partners across various industries	Safety, stability, effectiveness. A focus on results, professional development, adherence to corporate standards and a high level of responsibility among all employees	"Convenient and economical!" A discounter offering a wide product range at fair prices – the "ATB" Corporation's own retail format. Maximum quality at the lowest price
Silpo	Creating joy. Making guests happy	A place of joy, emotions and gastronomic discoveries. Creating experiences that guests will want to return for	Innovation – generating new ideas, embracing boldness and experimentation. A cohesive team – shared goals, successes and setbacks, mutual support and development. Motivation – treating employees with the same care as Guests and supporting work–life balance. Honesty, openness and trust – trusting colleagues and keeping promises. Hospitality – knowing and understanding Guests and delighting them. Joy – knowing how to have fun and daring to be playful and laugh at ourselves. Sustainable development – waste reduction and disposal, and efficient resource use. Continuous development – striving to grow and learn from best practices	"Silpo is about creating joy". An exciting experience – the atmosphere and design aim to exceed Guests' expectations and turn visits into a true gastronomic journey. A distinctive, Guest-oriented product range designed to delight. Personalised service in the chain's supermarkets, food courts and food halls – bringing Guests sincere smiles and genuine conversations
Novus	Making shopping convenient, accessible and beneficial for each of us	To be a retail leader	Care – our customers are our focus. We immerse ourselves in their experiences, identifying areas that need attention and improvement. Only a professional team can make this possible, so we create opportunities for every employee to grow and develop. Reliability – we are a reliable partner and employer with international experience: honest, stable and dependable. Rationality – common sense in everything we do	As the chain has developed, its positioning has shifted from "Novus Is Worthy of Your Trust", based on European rationality, practicality and technological sophistication, to "We Do It Because We Love It", reflecting an identified customer need for benevolence and empathy under current conditions. Novus positions itself as a Ukrainian business that does everything with love for its audience and its country, while caring for its employees, its customers and itself

End of Table 1

Supermarket chains	Mission	Vision	Values	Positioning
Fora	Ensuring food affordability and physical accessibility	Opening welcoming stores in every neighbourhood, where people can shop conveniently and comfortably	Service orientation – creating comfort by caring for everyone. Fostering human-centredness, where every Guest and SuperFora team member matters. Reliability – ensuring transparency in relationships with Guests, Partners and SuperFora team members. Innovation – developing a culture that encourages and supports ideas for sustainable business development. Productivity – working in synergy to deliver effective, clear solutions while maintaining work–life balance	"Fora Is Care in Action". Nearby, close to home, just a few steps away. Fora is care in action, so its stores are located wherever they are most convenient for every Guest: in a neighbouring building for quick purchases of essential groceries; along a main road for a stop on the way home; and in small towns and villages where local residents previously had no opportunity to buy fresh food close to home
Varus	Improving Ukrainians' lives and making them a little happier. Becoming our Customers' favourite store by solving their problems every day and anticipating their expectations	Satisfying customers with a wide selection of products at affordable and attractive prices by developing e-commerce, expanding the coverage of our own delivery service and scaling up online ordering	Teamwork – we are a team committed to shared results and mutual assistance. Expertise – we believe that each of us is an expert in our field. Effectiveness – every step we take serves the ultimate result. Efficiency – we use the company's resources efficiently and rationally. Support – we value what we do for one another and take pride in our achievements. Innovation – we generate ideas and seek unconventional solutions	"Food Variety Every Day!" Combating culinary monotony. Culinary variety for every customer, using everyday ingredients

Source: developed by the author.

All the supermarket chains under study consciously develop their brand identities and ensure that their brand images remain relevant to contemporary conditions, either by changing their positioning or by strengthening its emotional dimension. This is driven by a contemporary consumer trend identified in this study and corroborated by other research: the need for positive emotions (Retailers, 2026), which is consistent with the principles of the experience economy. Unlike "ATB", "Silpo", "Novus" and "Fora", discussed above, the "Varus" supermarket chain (Omega LLC) has introduced the character "Varusiatko" into its brand identity, creating a strong association with the brand that helps differentiate it from competitors. The chain's objective is to "satisfy customers with a wide selection of products at affordable and attractive prices", while its positioning is expressed as "Shop with Us for Comfort and Value!" (Varus website (LLC "OMEGA"), n. d.).

Overall, "Varus" communicates a more rational approach to customer interaction, emphasising value for money. At the same time, the brand's mission is to "improve Ukrainians' lives and make them a little happier" by promoting the concept of "Food Variety Every Day" and offering "culinary variety for every customer, using everyday ingredients". To promote the "VARUS" brand and its private label "Varto", the chain collaborated with the well-known culinary expert Yevhen Klopotenko between 2020 and 2022, incorporating his image into the packaging design of products sold under this label. As part of the collaboration, the expert supported Ukrainians at every stage of food preparation, starting with the selection of "Varto" products in supermarkets. He shared recommendations for preparing dishes with these products on social media, held masterclasses for "Varus" customers, including in supermarkets, and published an exclusive book for the chain's customers, "Borshch and What to Serve with It", as part of a marketing campaign, among other activities. Yevhen Klopotenko's image resonates with the chain's target audience and aligns with its brand personality. This collaboration also reflects the principles of the experience economy by engaging customers in developing national consciousness through the preparation of national dishes, thereby fostering a positive immersive customer experience.

These characteristics of the brand architecture and positioning of FMCG supermarket chain brands reflect both their strategic development priorities and the value systems through which they build customer relationships in the digital environment. However, the contemporary customer experience is shaped not only by communication messages and brand image but also by actual business practices, expressed through social responsibility and the implementation of sustainable development principles. The following analysis therefore examines how FMCG brands' economic, social and environmental initiatives are integrated into the customer experience and strengthen its immersive character, building trust, empathy and long-term customer loyalty.

1.2. Social responsibility and sustainable development of FMCG brands in shaping the customer experience

Within the framework of sustainable development, ATB-Market LLC harmoniously combines economic and social initiatives, through low prices and regular discounts for the country's residents, with environmental initiatives. These include the use of energy-efficient LED lighting systems and alternative energy solutions, such as solar panels, inverters, battery packs and solar carports; phasing out harmful plastic and replacing it with bags containing a patented biodegradable component and bags made from corn starch; introducing a specially designed heat recovery system that captures heat generated by refrigeration equipment and uses it for heating; and switching to reusable pooled containers, among other measures. In 2023, ATB's positioning was complemented by the message "a network of Ukrainian resilience, a stronghold of the country's food security". During the war, ATB-Market LLC has donated more than UAH 2 billion to the Armed Forces of Ukraine, medical institutions, rescue services and affected communities (Website of LLC "ATB-Market", n.d.; Symonenko, 2026).

The environmental initiatives implemented by the "Silpo" supermarket chain as part of its sustainable development approach include (Silpo-Food LLC, 2025): a project for the separate collection of recyclable materials; a battery collection initiative for recycling in partnership with the nationwide environmental movement "Batteries, Surrender!" (involving all the brands under study and other well-known Ukrainian retail brands); phasing out refrigeration equipment that uses greenhouse gases (HFC refrigerants), the largest source of carbon emissions in the retail sector, and replacing it with equipment that uses carbon dioxide (CO_2) as a refrigerant; introducing a "Do Not Print a Paper Receipt" option in the updated mobile application, since paper receipts are rarely recycled owing to the presence of bisphenol A in thermal paper (the initiative's slogan is "Our Planet Is Better Off Without Receipts"); and environmentally friendly initiatives encouraging guests to shop without plastic bags by using reusable shopping bags and mesh bags for fruit and vegetables, and to buy coffee in their own cups, among other measures.

Silpo-Food LLC employees, known as "Pereversh nyky" ("those who exceed expectations"), have access to career development and training programmes. The company also maintains its own YouTube channel with training videos. Additional employee benefits include health and life insurance, gym access, language courses and employee discounts. An employee support centre and numerous other programmes are also available. An analysis of these initiatives demonstrates an equally caring approach to external customers – guests – and internal customers – employees.

The brand has shifted its positioning from the market for goods and services to the market for experiences. It consistently fulfils its stated commitment to making people happy and creating joy, establishing itself as a benchmark among the companies under study for implementing experience

economy principles and moving towards lovemark status among loyal guests and employees. Notably, "Silpo" does not calculate the return on investment in its designer supermarkets, describing their creation as retailtainment – providing experiences in retail through entertainment. Management explains this approach through its belief that an emotionally engaging offering delivers strong financial performance (BrandVoice, 2023). This expresses love for guests and trust, generating emotions and strengthening their connection with the brand.

As a result of implementing experience economy principles and systematically working towards lovemark status among its guests, the "Silpo" supermarket chain has also gained recognition from industry peers. For several consecutive years, including 2025, it has won the "FMCG Supermarket of the Year" category at the Ukrainian Retail Association's RAU Awards (Symonenko, 2025).

In 2025, the social responsibility of "Novus" as a dimension of sustainable development was characterised by increased investment in energy independence, support initiatives and employer brand development. Amid energy challenges, Novus Ukraine LLC invested UAH 385 million in ensuring uninterrupted operations across the chain, including generators, backup power sources and the development of its own solar power generation (Business News from Ukraine, 2025). By the end of 2025, the company planned to have 15 sites operating with its own solar power systems, with a total capacity of 3.34 MW, and to implement a Building Management System (BMS) for remotely managing stores' energy consumption. The company also purchased its first corporate electric vehicles to reduce its carbon footprint and continues to develop environmentally oriented technological solutions (Business News from Ukraine, 2025).

The social dimension of the brand's sustainable development is implemented through support for the population and the development of its corporate culture. Since the start of the full-scale war, "Novus", together with the Food for Ukraine charitable foundation, has systematically provided assistance to Ukrainian families and communities, fostering a socially responsible model of interaction between business and society. At the same time, the company continues to develop its employer brand: in 2025, the chain was included in Delo.ua's list of Ukraine's top 100 employers for the second time, while its Human Resources Director, Kateryna Tsybur, was named among the country's top 15 HR directors (Troyanov, 2025). Through large-scale charitable projects, the chain raised more than UAH 200 million in 2025 for food, medical equipment and other assistance for the population, as well as for the needs of the Armed Forces of Ukraine.

The increased focus on energy efficiency, environmental sustainability, employee well-being and community support indicates the transformation of "Novus" from predominantly rational positioning towards a human-centred model of interaction with customers and employees. This approach aligns with contemporary trends in the development of the experience economy, in which social responsibility, empathy and care

become important factors in building trust, creating positive customer experiences and fostering long-term loyalty to an FMCG brand.

Brand health tracking conducted by "Novus", covering brand awareness, image characteristics and category-specific attributes, revealed changes in Ukrainians' values during the war. Customers have become more rational in their purchasing decisions and more attentive to prices and promotions (Osijek, 2025). At the same time, everyone in Ukraine today is experiencing loss and has a subconscious need for empathy from others. By demonstrating humanity, benevolence and empathy in their positioning, initiatives and everyday actions, brands can therefore create and sustain positive experiences for both external and internal customers, build and maintain trust, and address the economic, social and environmental objectives of sustainable development.

In implementing sustainable development principles, the "Fora" supermarket chain continues to integrate environmental, social and governance practices into its business model. The company promotes energy efficiency and energy independence, upgrades stores' building services systems, introduces modern heat recovery technologies and continues to use photovoltaic installations to meet part of its energy needs. As part of its environmental policy, the chain supports separate waste collection, reduced plastic use, the digitalisation of document workflows and the development of electric vehicle infrastructure. Improving the energy efficiency of retail premises and ensuring uninterrupted store operations amid energy challenges remain important priorities (Website of LLC "FORA", n. d.).

The social dimension of the "Fora" brand's sustainable development is implemented through a human-centred corporate culture and support for employees, whom the company calls "SuperFora team members". Following the refresh of the overall "Fora" brand, its employer brand was also refreshed, reinforcing its positioning as "Work That People Need" (Osijek, 2024). In 2025, the chain became the largest employer in the Kyiv region, with more than 9,000 employees, demonstrating the scale of the brand's social role in the region (Fixygen.ua, 2026). The company develops employment programmes for veterans, young people and people with disabilities, supports internal career pathways and continues to invest in staff training, the development of a service culture and the digitalisation of HR processes. As part of its employer brand development, "Fora" places increasing emphasis on job security, health insurance, employee support programmes delivered through partnerships, corporate training and the creation of a comfortable working environment. The company actively introduces digital solutions to optimise business processes and internal communication, contributing to more effective management and an improved employee experience (Website of LLC "FORA", n. d.; Dudka, 2026).

Thus, "Fora" is gradually shifting its positioning from a chain of stores "close to home" towards a socially responsible FMCG brand that creates positive customer experiences through care, accessibility, service orientation and social interaction. Implementing sustainable development principles in

combination with digital technologies helps build trust, emotional attachment and long-term loyalty among both external and internal customers of the brand.

In implementing sustainable development principles, the "Varus" supermarket chain (Omega LLC) continues to integrate environmental initiatives into its development strategy and operations. The company invests in energy-saving projects; processes food waste and products of animal origin through specialist licensed processors; replaces fluorescent lamps with LEDs; has introduced a system that recovers heat from refrigeration equipment to heat sales areas and provide hot water; has implemented an energy management system; has replaced Freon in its cooling systems with an environmentally safe refrigerant; has installed sensor-operated taps to conserve water and motion sensors to save electricity; and offers customers reusable shopping bags, biodegradable bags and paper bags.

The company's social responsibility is reflected in a set of corporate competencies expected of all employees, regardless of their position: customer orientation, openness to new ideas, flexibility, teamwork and initiative. Career progression opportunities are available, with 52% of vacancies for administrative positions filled from the internal talent pool. "Varus" offers work placement programmes for university students. An employee motivation system is in place, alongside programmes for internal and external training and professional development. In addition, "Varus" is expanding its digital services and process automation: the chain is developing its mobile application, loyalty programmes, Scan&Go services, electronic receipts and personalised offers, combining functional benefits with the creation of positive customer experiences in the digital environment (Varus website (LLC "OMEGA"), n. d.).

The synthesis of the research findings indicates that contemporary FMCG brands are transforming sustainable development from an additional area of activity into an integral component of the customer experience and digital positioning. Energy efficiency, environmental initiatives, employee support, charitable projects, employer brand development and empathy in communications create both functional brand value and an emotional connection with consumers, strengthening trust, loyalty and companies' competitive advantages in the digital environment.

The identified values, principles of interaction and human-centred approach of the FMCG brands under study are further reflected in the supermarket chains' marketing programmes and digital communications.

2. Marketing programmes of FMCG brands in the digital environment

As part of the investigation into FMCG brand positioning based on the principles of the experience economy and sustainable development, each brand's distinctiveness was analysed in terms of the visual expression of its

stated mission, values and positioning (*Table 1*), as well as its communications based on brand personality (*Table 2*). The analysis draws on Carl Gustav Jung's concept of psychological archetypes (Jung, 2024), first applied to marketing by Margaret Mark and Carol S. Pearson in their book "The Hero and the Outlaw: Building Extraordinary Brands Through the Power of Archetypes" (Mark & Pearson, 2001). The concept of brand archetypes is now widely used. It enables brands to develop a coherent system of emotional positioning, establish a recognisable style of integrated marketing communications, ensure consistency between the visual and semantic elements of branding, and strengthen emotional connections with consumers in the digital environment.

Table 2

Brand personality of the supermarket chains under study

FMCG brand		Archetype		Positioning	Tone of Voice
ATB		Primary	Caregiver	Service and belonging	Caring and straightforward
		Secondary	Everyman		
Silpo		Primary	Magician	The magical power of innovation and creativity	Humorous
		Secondary	Creator		
Novus	NOVUS	Primary	Hero	Masterful service	Supportive and intellectual
		Secondary	Caregiver		
Fora	фора	Primary	Everyman	Care	Friendly
		Secondary	Caregiver		
Varus	VARUS	Primary	Innocent	Safe entertainment and fun	Playful
		Secondary	Jester		

Source: developed by the author.

The initiatives and activities shared by the supermarket chains under study are shaped by the specific nature of retail operations and contemporary consumer needs and behaviour, requiring attention to improving the immersive experience of both external and internal customers. In particular, all the brands have private labels, import products directly, actively participate in charitable initiatives, develop micro-brands for initiatives and projects, implement sustainable development principles, and actively introduce technological innovations into business processes and digital marketing technologies into customer interaction. They also operate online stores, mobile applications and delivery services, and develop loyalty programmes.

Table 3 compares the marketing programmes of the supermarket chain brands under study according to the core digital marketing tools of the 4Cs framework, which considers brands' presence in the digital environment alongside the traditional 4Ps.

Table 3

Comparison of digital marketing programmes of the supermarket chain brands under study

Marketing tools (4Cs)	Supermarket chains				
	Silpo	**ATB**	**Novus**	**Fora**	**Varus**
Type of economic activity	47.11 Retail sale in non-specialised stores with food, beverages or tobacco predominating				
Products (private labels)	Fozzy Group private labels: "Premiia", Premiya Select, "Povna Chasha", Riki Tiki. Silpo private labels: Kraftiar, Zelena Kraina, feels good	"De Luxe Foods & Goods Selected" – upper price segment; "Svoia Liniia" – middle price segment; "Rozumnyi Vybir" – lower price segment; "Den u Den" – between the middle and lower price segments	Novus, Marka Promo	Promo Fozzy Group private labels: "Premiia", "Povna Chasha", Riki Tiki. Fora private labels: "Zirkovyi Vybir" – middle price segment; favore – premium price segment	"Chysta VyhoDA" – economy segment; "Domashnii Koshyk", "VARTO", "Vyhoda" – lowest prices; Varto Soft, Varto Clean, BOHEMA, Origin, Trixi
Core price segment	Upper-middle	Low	Upper-middle	Middle	Middle
Online sales channels	Official online store silpo.ua	Official online store atbmarket.com	Official online store novus.ua; grocery delivery service from hypermarkets zakaz.ua	Official online store shop.fora.ua	Official online store varus.ua; go.varus.ua service; Varus Pick-up Point service
Offline sales channels	Silpo and LeSilpo supermarkets; designer supermarkets with distinctive styles; an innovative shop-in-shop format in collaboration with MVM My Home	The ATB Corporation's own store format – discounters	Novus supermarkets; "Mi Market" minimarkets; two "Khapaika" discounters	Fora supermarkets; to-go formats; Fora Express	Varus supermarkets; Varus Home formats; a DarkStore in Kyiv; to-go formats; "a store close to home"
Online promotional tools	Website; mobile application; social media: YouTube, Facebook, Instagram, TikTok, X; messaging platforms: Telegram, Viber; TikTok collaborations; dating website; mobile games; user-generated content (UGC); executive interviews published on online platforms	Website; ATB-Market mobile application; social media: YouTube, Facebook, Instagram, X; Viber and Telegram chatbots; ATB Arena gaming application	Website; mobile application; social media: Facebook, Instagram, YouTube; opinion leaders	Website; mobile application; social media: YouTube, Facebook, Instagram; Telegram messaging platform	Website; mobile application; bots; SMS; messaging platforms: Telegram, Viber, Facebook Messenger; social media: Facebook, Instagram, X, YouTube

End of Table 3

Marketing tools (4Cs)	Supermarket chains				
	Silpo	ATB	Novus	Fora	Varus
Online advertising	Video advertising on YouTube and Meta social media platforms; banner advertising; brand image and promotional campaigns	Video advertising on YouTube; banner advertising; price-based and thematic promotional campaigns	Video advertising on YouTube and online platforms; brand image campaigns and price offers	Video advertising on YouTube and Meta social media platforms; brand image and promotional campaigns	Video advertising on YouTube and Meta social media platforms; brand image and promotional campaigns
Online advertising objectives	Building an emotional connection with the brand; engaging a young target audience; promoting shop.silpo.ua, delivery, the LOKO delivery service, the PLIUKHS subscription, brand projects, offers for Guests and job opportunities, among others	Increasing the number of active social media followers; expanding reach; combating fake content (Facebook, Instagram, Telegram); increasing brand awareness; strengthening loyalty	Increasing brand awareness among the target audience; improving brand image attributes; attracting new customers; increasing market share; achieving performance outcomes (website visits, subscriptions, leads and sales)	Brand image and conversion objectives: announcing new store openings; promoting the mobile application, the shop.fora.ua online store and free delivery, the training school, ForaCafe, discounts in physical stores, price offers and the benefits of working at "Fora", among others	Promoting special offers and discounts on YouTube; increasing brand awareness on social media; promoting the mobile application and delivery
Offline promotional tools	"Silpo" radio; collaborations; themed projects; gastronomic festivals; charitable events; performances and workshops within the Festerudze project; tasting workshops; teaching by the Marketing Director on educational programmes; integration of art into creative events	Billboards; television and radio advertising; collaborations with the entertainment industry; product placement; in-store audio advertising	Presentations by Novus executives at business forums; participation in charitable events; television, metro and outdoor advertising; in-store radio; employee ambassadors; in-store communications	Charitable events; rebranding; outdoor advertising; radio; in-store campaign materials, including price labels, shelf stoppers, audio and video content	Interviews with the chain's co-founder and participation in business conferences; mass media; collaborations; workshops, including in supermarkets; charitable campaigns

Source: developed by the author.

The comparison of digital marketing programmes of the FMCG brands under study indicates a high level of digitalisation in communications and omnichannel interaction with consumers. However, each chain implements its own marketing model according to its price segment, positioning and chosen brand archetype. Brands in the middle and premium segments (Silpo, Novus) emphasise emotional customer experiences, immersive communication formats, brand projects and community building around the brand, whereas discounters and mass-market brands (ATB, Fora, Varus) focus on value propositions, service orientation, accessibility and sales promotion through digital channels.

The findings confirm that contemporary digital marketing of FMCG brands extends beyond product promotion and is evolving into a system for developing a comprehensive customer experience that combines functional value, emotional interaction, social responsibility and digital technologies.

Conclusions

The contemporary development of FMCG brands in the digital environment is characterised by a shift from a product-oriented to an experience-oriented model based on an immersive customer experience. This experience is shaped within the experience economy, where emotional experiences, social interaction and digital communications become decisive, confirming the proposed hypothesis.

The brand architecture and positioning of the supermarket chains under study reflect different strategic models of consumer interaction and demonstrate a gradual strengthening of the emotional dimension in their communication policies. Social responsibility and sustainable development principles are important factors in building trust, fostering empathy and creating positive customer experiences in the digital environment.

Digital marketing programmes of FMCG brands are evolving towards omnichannel integration and personalised consumer interaction through digital marketing tools and the 4Cs framework. Combining the experience economy, digital technologies and socially responsible practices enhances the quality of the customer experience, increases consumer loyalty and subjective well-being, and thereby strengthens brand competitiveness.

Promising directions for further research include an in-depth analysis of how brands influence the development of immersive customer experiences and consumer behaviour; the development of appropriate methods for evaluating the effectiveness of marketing communications in the digital environment; and an examination of the role of social interaction and sustainable development principles in enhancing the emotional value of FMCG brands.

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BRANDS OF UKRAINIAN CITIES

Amid growing global and regional competition among cities, territorial branding is becoming particularly important as a tool for shaping their unique identities. A city's brand not only serves as a means of visual differentiation but also becomes a strategic resource that ensures the territory's recognition, attractiveness, and competitiveness. This is particularly relevant today, as some Ukrainian cities face post-war reconstruction and need to attract partners, investments, and resources. In this context, branding serves not only as an element of communication policy but also as a mechanism for the city's development and positioning at the national and international levels. At the same time, there is currently no comprehensive understanding of the level of development of branding in Ukrainian cities, which necessitates a scientific analysis of the issue. The hypothesis is put forward that the branding of Ukrainian cities is fragmented in nature and that the vast majority of cities do not use it as a tool for territorial development and positioning. During the study, general scientific and specialized methods were applied: analysis and synthesis, induction and deduction, grouping, structural-logical analysis, logical generalization of results, and graphical analysis. The branding of Ukrainian cities is examined. The distribution of administrative-territorial units and territories of territorial communities in Ukraine is presented. The distribution of cities by region is provided. All Ukrainian cities are analyzed for the presence of a brand or logo. The study identified cities that have a logo and a fully developed brand, as well as those that lack them. It demonstrated and analyzed the visual identities of branded cities, listing their slogans, city council websites, and

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БРЕНДИ УКРАЇНСЬКИХ МІСТ

В умовах зростання глобальної та регіональної конкуренції між містами особливого значення набуває брендинг територій як інструмент формування їх унікальної ідентичності. Бренд міста виконує не лише функцію візуальної диференціації, але й стає стратегічним ресурсом, що забезпечує впізнаваність, привабливість та конкурентоспроможність території. Це набуває особливої актуальності в умовах, коли частину українських міст чекає повоєнна відбудова та постає необхідність у залученні партнерів, інвестицій та ресурсів. У таких обставинах брендинг виступає не лише як елемент комунікаційної політики, але й як механізм розвитку та позиціонування міста на національному й міжнародному рівнях. Водночас нині відсутнє цілісне уявлення про рівень розвитку брендингу українських міст, що зумовлює потребу у його науковому осмисленні. Висунуто гіпотезу, що брендинг міст України має фрагментарний характер і більшість міст не використовує його як інструмент територіального розвитку та позиціонування. Під час проведення дослідження застосовано загальнонаукові та спеціальні методи: аналізу та синтезу, індукції й дедукції, групування, структурно-логічний, логічного узагальнення результатів та графічний. Розглянуто особливості брендингу українських міст. Представлено розподіл адміністративно-територіальних одиниць та територій територіальних громад України. Наведено розподіл міст за регіонами. Досліджено усі українські міста на наявність бренду чи логотипу. Виявлено міста, що мають логотип та повноцінний бренд, а також ті, у яких вони відсутні. Продемонстровано й проаналізовано візуальну ідентичність брендованих міст, вказано їх слогани,

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tourism websites. The process of developing brands for Ukrainian cities and the significance of their logos were examined. The proportion of presented and approved city brands and logos was determined.

Keywords: brand, branding, territory branding, territorial brand, city brand, city branding.

сайти міськрад та туристичні сайти. Розглянуто послідовність формування брендів українських міст та значення їх логотипів. Визначено частку презентованих та затверджених брендів й логотипів міст.

Ключові слова: бренд, брендинг, територіальний брендинг, бренд території, бренд міста, брендинг міст.

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Introduction

Territorial branding is a complex and multifaceted process aimed at shaping a cohesive identity for a locality, taking into account its cultural and historical heritage, geographical location, natural resources, tourist attractions, and socio-economic characteristics. In the current context of the transformations Ukraine is undergoing, the branding of territories – particularly cities – is becoming particularly relevant. It serves as a tool for raising profile and fostering a positive image, which can contribute to the country's post-war reconstruction and help attract investment, resources and tourist flows. Effective branding ensures that cities are clearly positioned at national and international levels, creates lasting associations and enhances their competitiveness.

At the same time, city branding in Ukraine is currently often fragmented and largely limited to the design of a logo without a comprehensive brand development strategy, whilst information regarding the existence of Ukrainian city brands and their visual identity remains unsystematised. Closing this gap will make it possible to assess the level of branding development in Ukraine, establish a foundation for further research, identify best practices and develop effective development strategies.

Foreign researchers have made a significant contribution to the development of the theoretical foundations of city branding. In his article "The Anholt-GMI City Brands Index: How the world sees the world's cities", Anholt (2006) examined the characteristics of how cities' international reputations are formed and proposed "The city brand hexagon" model. This model evaluates a city brand across six key dimensions: the presence (the city's international presence), the place (the physical aspects of the city), the potential (the city's opportunities), the pulse (the city's vibrancy and appeal), the people (the city's residents), the prerequisites (the city's amenities and infrastructure). The researcher also emphasized that a city brand is shaped not only by marketing communications but, above all, by the actual characteristics of the territory and how the territory is perceived globally.

For his part, Dinnie (2011), in "City Branding: Theory and Cases", combined theoretical approaches to city branding with practical case studies from various cities around the world, highlighting the specific features of the development and promotion of city brands. Alperytė & Išoraitė (2019)

examine the theoretical foundations of city branding and demonstrate how it is applied, using the example of Lithuanian cities. Dudek-Mańkowska and Grochowski (2019) examine how the creative industries and the creative potential of cities are utilised in the city branding strategies of Polish cities. Shirvani Dastgerdi and De Luca (2019) examine how city branding shapes and reinforces a city's reputation through its identity, image and communication within the context of global competition between cities; they also analyze various practices based on 24 case studies from cities around the world. Lemmetyinen et al. (2025), drawing on an analysis of ten European cities, argue that successful place branding is based on a combination of creative industries, social inclusion and sustainable development.

In the "Elgar encyclopedia of city and place branding", Oliveira et al. (2025) provide an overview of current trends and approaches in the field of city and place branding, emphasising the challenges and opportunities for the sector's development in the context of digitalisation, in particular the role of artificial intelligence, digital experiences and integrated marketing communications, as well as the interplay between politics, culture and territorial identity in shaping a place's brand.

Alongside foreign scientific research, various aspects of regional branding are also being actively studied by Ukrainian researchers. Bilovodska and Haidabrus (2012) examined the objectives of city branding for the state, developed an approach to formulating a city branding strategy, and adapted Anholt's model for assessing the attractiveness of a city brand to Ukrainian cities. Kuksa (2018) explores the essence and characteristics of territorial branding, specifically examining the brands of certain Ukrainian cities. Sydoruk et al. (2021) analyze the development of a tourism brand identity using the city of Zaporizhzhia as an example. Niecheva et al. (2021) analyze the current use of branding elements in promoting a tourist destination, using the city of Odesa as an example.

For their part, Potorii and Sapfirova (2023) highlight the need for visual design in cities as part of their branding. Pavlovskyi et al. (2023) explore the theoretical and methodological aspects of developing city branding as a tool to enhance a city's appeal. Kohut and Havryliuk (2024) view city branding as a tool for strategic development, examine target audiences and the goals of city branding, and, in particular, have developed a brand development strategy for Lviv. Zabarna (2024) examines branding as an element of European integration for agricultural regions and discusses the advantages, characteristics, and tools of branding agricultural territories. Dudkina and Chykalo (2024) summarize conceptual approaches to territorial brand management and examine branding as a tool for enhancing the competitiveness of a territorial community.

Kapuza (2025) examines territorial branding as a factor in shaping a competitive image and fostering a region's socioeconomic development. Ustik (2025) summarizes the scientific foundations of urban branding and explores how they translate into investment outcomes. Okseniuk (2025)

examines key approaches to branding regions in Ukraine, taking into account motivational factors that influence the formation of a positive image of territories and their strategic development. Kulyniak (2026) analyzes the prospects and challenges of applying territorial branding in the digital environment to stimulate local development – specifically using the city of Lviv as an example – and develops recommendations for the effective management of digital territorial branding.

In addition, open online sources contain articles presenting examples of logos and slogans of Ukrainian cities (Shyian, 2020, February 25), as well as examining the visual identities of Ukrainian regions (Kovalchuk, n. d.).

Despite the existence of individual studies by various scholars regarding the branding of Ukrainian territories, certain aspects remain insufficiently explored and require systematization:

- there is no unified database (register) of Ukrainian city brands – there is no comprehensive list of territories with approved brands;
- the visual identity of Ukrainian cities remains undefined;
- existing research is fragmentary in nature – scientific publications focus primarily on theoretical aspects or individual case studies, rather than on a comprehensive overview of branding for all cities in the country.

Consequently, there is a need to form a comprehensive picture of the current state of city branding in Ukraine. To achieve this, it is necessary to examine all Ukrainian cities for the presence of a brand and to identify its key characteristics (status, visual identity, year of creation, etc.).

The purpose of the article is to identify Ukrainian cities that have a brand or logo and to systematize the collected information.

To achieve the stated goal, the following tasks have been defined:

- examine the distribution of administrative-territorial units in Ukraine;
- analyze official sources (city council websites, city brand books);
- identify Ukrainian cities that have a brand or logo;
- determine the visual identity of Ukrainian cities;
- systematize and summarize the obtained results.

The study is based on the hypothesis that only some of Ukraine's cities have an officially established brand, while a significant number of cities do not use branding as a tool for territorial development and positioning.

To test the proposed hypothesis, the following general scientific and specialized research methods were used: analysis and synthesis, induction and deduction, grouping, structural-logical method (for examine the presence of brands and logos of Ukrainian cities), logical generalization of results (for formulate conclusions regarding the study) and graphical method (for the creation of figures).

Publications of domestic and foreign scientists, official state information resources, in particular the Codifier of Administrative Territorial Units and Territories of Territorial Communities (CATUTTC), official

websites of local authorities, city brand books and other online resources served as the information base of the research.

The main body of the article examines the distribution of administrative-territorial units and territorial communities in Ukraine. In particular, the distribution of cities across the Regions is illustrated. A total of 461 Ukrainian cities were surveyed to determine the presence of a brand or logo. These cities are divided into three groups based on the analysis: cities with a brand; cities with a logo; and cities without a brand or logo. In addition, for each city with a visual identity, the logo is presented, and its structure, colour palette, and theme are analysed. The slogan, the year the brand was established, the city council's website, and the tourism website are also provided. The proportion of cities with a fully developed brand and those with only a logo, whether officially approved or merely presented, has been determined.

1. Administrative-territorial division of Ukraine

Without an analysis of the competitive environment, it is impossible to create a clear identity for a territory that allows it to be differentiated from others. Accordingly, building a successful city brand requires thorough research of competitors – an analysis of other cities' brands. To analyze the brands of Ukrainian cities, we first need to understand the exact number of settlements. According to the Codifier of Administrative-Territorial Units and Territories of Territorial Communities and its Annex (Ministry of Communities and Territories Development of Ukraine, 2025) dated January 14, 2025, there are 31 748 territorial units in Ukraine; their distribution is presented in *Table 1*.

Table 1

Distribution of administrative-territorial units and territories of territorial communities of Ukraine

First level	Second level	Third level	Fourth level			Addi-tional level	Total number of objects
Autonomous Republic of Crimea, region, city with special status	A district in the Autono-mous Republic of Crimea or in the region	Territorial community	City	Settle ment	Village	City district	
Autonomous Republic of Crimea	10	303	17	88	945	3	1366
Vinnytsia Region	6	63	18	155	1329	–	1571
Volyn Region	4	54	11	22	1054	–	1145
Dnipropetrovsk Region	7	86	20	100	1380	18	1611
Donetsk Region	8	66	52	327	919	21	1393
Zhytomyr Region	4	66	12	61	1595	2	1740
Zakarpattia Region	6	64	11	19	577	–	677
Zaporizhzhia Region	5	67	14	66	870	7	1029

End of Table 1

First level	Second level	Third level	Fourth level			Additional level	Total number of objects
Autonomous Republic of Crimea, region (Region), city with special status	A district in the Autonomous Republic of Crimea or in the region	Territorial community	City	Settlement	Village	City district	
Ivano-Frankivsk Region	6	62	15	44	746	–	873
Kyiv Region	7	69	26	34	1122	–	1258
Kirovohrad Region	4	49	12	43	972	2	1082
Luhansk Region	8	37	37	211	678	4	975
Lviv Region	7	73	44	35	1849	6	2014
Mykolaiv Region	4	52	9	87	815	4	971
Odesa Region	7	91	19	55	1100	4	1276
Poltava Region	4	60	16	34	1789	5	1908
Rivne Region	4	64	11	19	996	–	1094
Sumy Region	5	51	15	72	1402	2	1547
Ternopil Region	3	55	18	18	1022	–	1116
Kharkiv Region	7	56	17	195	1539	9	1823
Kherson Region	5	49	9	110	577	3	753
Khmelnytskyi Region	3	60	13	29	1409	–	1514
Cherkasy Region	4	66	16	115	723	2	926
Chernivtsi Region	3	52	11	8	398	–	472
Chernihiv Region	5	57	16	86	1407	2	1573
Kyiv City	–	–	–	–	–	10	10
Sevastopol City	–	–	–	–	–	4	4
Total:	136	1772	459	2033	27213	108	31721

Source: compiled by the author based on (Ministry of Communities and Territories Development of Ukraine, 2025).

As shown in *Table 1,* Ukraine comprises 24 Regions, the Autonomous Republic of Crimea, and two cities with special status, which together encompass 31 721 territorial units and territorial communities (hromadas), bringing the total to 31 748 units. The Lviv Region leads in terms of the number of territorial units, followed by the Poltava and Kharkiv Regions. The Chernivtsi Region, as well as the Zakarpattia and Kherson Regions, have the fewest settlements and territories. Accordingly, branding is most relevant for Regions with a large number of settlements. However, branding is beneficial for all territories, as it helps shape a unique identity and enhance their competitiveness. Branding is a useful tool for the development and positioning of all territories, regardless of their size or level of socioeconomic development.

2. Analysis of the presence of Ukrainian city brands

City branding is considered one of the most widespread forms of territorial branding, as cities compete extensively for investment, resources, and tourists. Moreover, cities tend to be more recognizable and widely known

than hromadas, settlements, and villages, which there are thousands. Currently, Ukraine has 459 cities and two cities with special status, bringing the total to 461. The distribution of cities by region in Ukraine is presented in *Figure 1*.

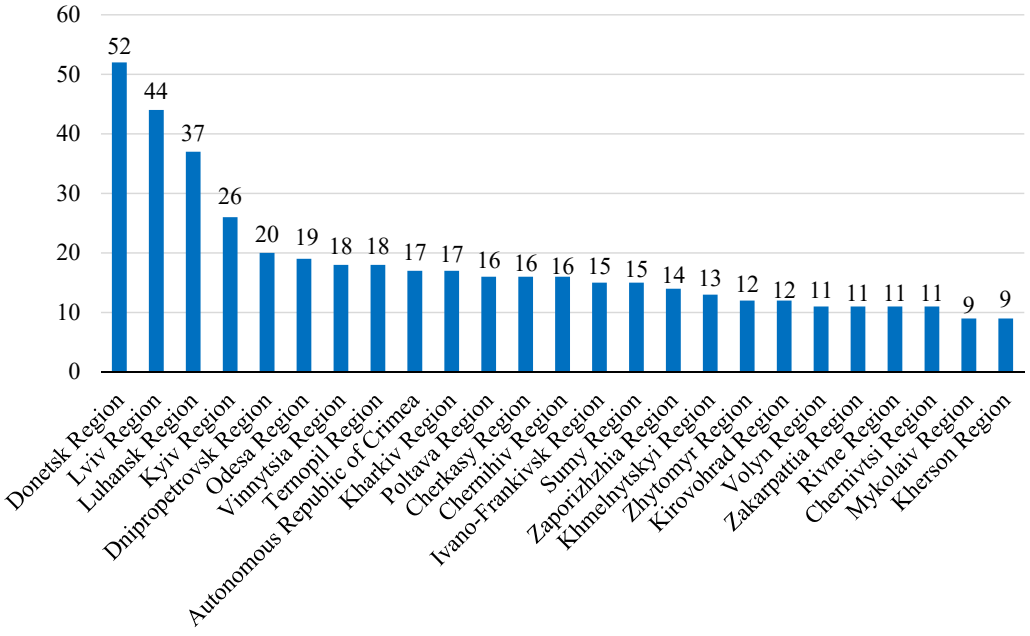


Figure 1. Quantitative distribution of Ukrainian cities by region

Source: compiled by the author based on (Ministry of Communities and Territories Development of Ukraine, 2025).

To search for information regarding the existence of a city brand (or logo), a complete list of cities was taken from the Codifier of Administrative-Territorial Units and Territories of Territorial Communities, dated January 14, 2025. (Ministry of Communities and Territories Development of Ukraine, 2025). Based on this list, a search was conducted for brands/logos for each city on the list. To do this, the following search terms were entered into Google: "city council of …", "tourism website of ...", "city brand of ..." та "city logo of ...", where "…" – represents the name of the city in the nominative singular case. The main sources of information were the official websites of city councils and city tourism portals, as well as approved and published brand books and decisions by local authorities on the implementation of a city brand or logo.

First, the city council's website was examined for the presence of a logo and references to the city's symbols, brand, or brand book. However, in most cases, information regarding the city's brand or logo was absent from the city council's website. Additionally, the city's official tourism website (where available) was reviewed, as most localities create brands specifically for tourism purposes. When such information was missing from these sites, the search for the city's brand or logo extended to the official social media

pages or accounts of city councils and city tourism information centers, as well as Ukrainian news outlets, the websites of information, design, and marketing agencies, regional media portals, and other online publications.

As a result of a comprehensive study, presented in *Table 2*, all Ukrainian cities (in quantitative terms) are classified into three categories: cities with a brand, cities with a logo, and cities without a brand or logo.

Table 2

Presence of Ukrainian city brands (quantitative dimension)

Region	Number of cities						Total number of cities
	with the brand		with the logo		no brand/logo		
	pcs	%	pcs	%	pcs	%	pcs
Autonomous Republic of Crimea	0	0	4	23.53	13	76.47	17
Vinnytsia Region	1	5.56	0	0	17	94.44	18
Volyn Region	2	18.18	1	9.09	8	72.73	11
Dnipropetrovsk Region	3	15.00	0	0.00	17	85.00	20
Donetsk Region	1	1.92	1	1.92	50	96.15	52
Zhytomyr Region	2	16.67	2	16.67	8	66.67	12
Zakarpattia Region	1	9.09	0	0	10	90.91	11
Zaporizhzhia Region	3	21.43	1	7.14	10	71.43	14
Ivano-Frankivsk Region	2	13.33	3	20.00	10	66.67	15
Kyiv Region	6	23.08	0	0	20	76.92	26
Kirovohrad Region	3	25.00	0	0	9	75.00	12
Luhansk Region	1	2.70	0	0	36	97.30	37
Lviv Region	8	18.18	2	4.55	34	77.27	44
Mykolaiv Region	2	22.22	0	0.00	7	77.78	9
Odesa Region	1	5.26	3	15.79	15	78.95	19
Poltava Region	2	12.50	1	6.25	13	81.25	16
Rivne Region	3	27.27	0	0	8	72.73	11
Sumy Region	1	6.67	0	0	14	93.33	15
Ternopil Region	1	5.56	1	5.56	16	88.89	18
Kharkiv Region	0	0	3	17.65	14	82.35	17
Kherson Region	3	33.33	0	0	6	66.67	9
Khmelnytskyi Region	3	23.08	0	0	10	76.92	13
Cherkasy Region	0	0	1	6.25	15	93.75	16
Chernivtsi Region	1	9.09	0	0	10	90.91	11
Chernihiv Region	2	12.50	0	0	14	87.50	16
City with special status	1	50.00	0	0	1	50.00	2
Total:	53	11.50	23	4.99	385	83.51	461

Source: compiled by the author.

The data in *Table 2* indicate that brands exist in only 11.5% of Ukrainian cities, while 4.99% possess only logos; the largest share of cities (83.51%) lacks any visual identity beyond official symbols, such as a coat of

arms and a flag. Accordingly, it is important to study the existing brands and logos of Ukrainian cities.

3. Research of brands and logos of Ukrainian cities

Table 3 shows the logos, slogans, city council websites and tourism websites of Ukraine's branded cities, arranged in chronological order by the year the brand was created.

The status of the brand is also defined: A (approved) – if there is confirmation of official approval of the brand/logo, P (presented) – when the brand/logo was presented to the community, but not officially approved. In addition, a visual analysis of the logos was carried out and their structure, colour palette and theme were determined.

Logos are classified into three types according to their structure: S – symbolic (containing only symbols, with no text), T – text-based (containing only text, with no symbols), and C – combined (containing both text and symbols).

Logos are categorised by colour palette as follows: M – monochrome (featuring one primary colour and its shades), T – two-colour (using two primary colours), P – polychromatic/multicolour (featuring three or more different colours).

The following types of logos have been identified by theme: A – architectural (the logo features architectural landmarks, historic buildings and structures, fortresses, town halls, towers, cathedrals, etc.), G – geographical (the logo features the contours of the territory, a map of it, the outlines of the terrain, the landscape, etc.), HR – heraldic (based on the city's coat of arms), H – historical (created based on the city's historical past), CS – a combination of symbols (the logo consists of a combination of several symbols, each with its own meaning), N – natural (the logo is based on natural objects: trees, plants, mountains, rivers, animals, etc.), SP – those that reflect the specialization of the city (the main elements of the logo are associated with the leading field of activity of the territory), S – symbolic (a logo based on a specific symbol, which may have one or more meanings), T – typographic (the logo is based on a typeface (text); there are no symbols).

Thus, out of 53 branded cities, 43 (81.13%) have an approved brand, while the remaining 10 cities (18.87%) have presented their brands but have not yet had them approved. All cities have created logos and have city council websites, which serve as a kind of "calling card" for the city. Almost all logos are accompanied by slogans, though there are a few instances (Dubno, Kropyvnytskyi, Oleksandriia, Chornobyl) where the brand lacks a slogan. In 24 of the 52 cities (46.15%), the city council's website mentions the city's brand, but in the majority (28 cities – 53.85%), it does not. As for tourism websites, they exist in 27 of the 52 cities (51.92%). Chornobyl is not included in these metrics because it is a city without a functioning local government and, accordingly, does not have a city council website or a tourism portal. At the same time, the city is included in the overall sample for branding analysis as a special case.

Table 3

Brands of Ukrainian cities

№	Year of brand creation	Brand status	City	Logo	Slogan	Source of the logo image	Logo analysis			City Council website	Brand information on the City Council website	Official city tourism website
							Structure	Colour palette	Logo theme			
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2010	A	Chernihiv		City of Legends	http://urbanua.org/eksperty/ukrayinski-eksperty/224	C	M	CS	https://www.chernigiv-rada.gov.ua/	–	https://chernihiv.travel/ua
2	2011	A	Kyiv		The City Where Everything Begins	https://lnk.ua/pQtabt7p7	C	P	CS	https://www.kmr.gov.ua/	–	https://gotokyiv.com/ua/
3	2011	A	Kherson		City of the Sun	https://grades.ua/portfolio-items/kherson-brand/	C	M	H	https://miskrada-ks.gov.ua/	–	–
4	2011/2019	A	Lviv		Lviv Open to the World	https://surl.li/bfaaza	C	P	A	https://city-adm.lviv.ua/	✓	https://lviv.travel/
5	2012	A	Myrhorod		City of Peace and Health	https://myrgorod.pl.ua/page/pro-misto/symvolika-mista	C	P	SP	https://myrgorod.pl.ua/	✓	–
6	2013	A	Boryspil		Start Here	https://lnk.ua/GN5NyZLc0	C	T	SP	https://borispol-rada.gov.ua/	✓	–

Continuation of the Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13
7	2013/ 2019	A	Kryvyi Rih	КРИВИЙ РІГ МІСТО ДОВЖИНОЮ В ЖИТТЯ	A City Spanning a Lifetime	https://kr.gov.ua/brend-mista	C	P	S	https://kr.gov.ua/	–	https://touristkr.com.ua/
8	2014	A	Pavlohrad	ПАВЛОГРАД	The Energy of the Past and a Boundless Future	https://lnk.ua/AWKwvj1Sw	C	T	S	https://pavlogradmrada.dp.gov.ua/	✓	–
9	2014	A	Ternopil	Тернопіль	Fine City of Ternopil	https://lnk.ua/A8Ufk0vVD	C	T	N	https://ternopilcity.gov.ua/	✓	https://visit.ternopil.ua/
10	2015	A	Rivne	РІВНЕ	(Rivne (Equal) for Everyone)	https://rvrada.gov.ua/portalfiles/1/216/2429/rivne_city_brand.pdf	C	T	CS	https://rivnerada.gov.ua/portal/landing	✓	–
11	2016	A	Zhovkva	ЖОВКВА КУЛЬТУРА В СЕРЦІ	Culture at the Heart	https://zhovkva-tour.info/brandbook.pdf	C	P	S	https://zhovkva-rada.gov.ua/golovna.html	–	https://zhovkva-tour.info/
12	2016	A	Kalush	МІСТО КАЛУШ	City of Kalush	https://lnk.ua/19O4exQBJ https://lnk.ua/Q4yFmTzik	C	T	SP	https://www.kalushcity.gov.ua/	✓	https://kalush-travel.com/(старий сайт)
13	2016	A	Mariupol	Маріуполь Вортий твоєї уваги	Worth Your Attention	https://mariupolrada.gov.ua/page/miska-simvolika	C	M	SP	https://mariupolrada.gov.ua/	✓	https://mistomariupol.com.ua/
14	2017	A	Dnipro	Дніпро Хвилююче місто	The exciting city	http://www.dniprodesign.dp.ua/projects/logo/	C	T	CS	https://dniprorada.gov.ua/uk	–	https://vidchuy.dp.ua/
15	2017	A	Zaporizhzhia	Запоріжжя Сім шляхів до пригод	Seven Paths to Adventure	http://identity.zaporizhzhia.city/	C	P	CS	https://zp.gov.ua/	✓	https://zaporizhzhia.city/

Continuation of the Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13
16	2017	P	Mala Vyska		A City That Gives You Wings	https://malavyska.tilda.ws/	C	P	H	https://mviskarada.gov.ua/	–	https://mala-vyska.tilda.ws/
17	2017	A	Melitopol		Right Here …	https://www.mlt.gov.ua/?r=posts.client.view&id=111	C	P	CS	https://www.mlt.gov.ua/	✓	https://tourism.mlt.gov.ua/ (старий сайт)
18	2017	A	Slavutych		Slavutych – City of New Ideas	https://lnk.ua/hDkPlHNDu	C	T	CS	https://e-slavutych.gov.ua/	✓	https://visitslavutych.com/
19	2017	P	Chornomorsk		The City Awaits	https://lnk.ua/NnnX64XAn	T	M	S	https://od.cmr.gov.ua/	–	–
20	2018	P	Bila Tserkva		A Map of Your Heart	https://lnk.ua/BshdNCjqn	C	P	G	https://bc-rada.gov.ua/	–	https://www.bctravel.com.ua/
21	2018	A	Drohobych		Drohobych – all the salt is in it!	https://white.com.ua/portfolio/city-branding/36/view	C	T	SP	https://drohobych-rada.gov.ua/	–	–
22	2018	P	Dubno		–	https://lnk.ua/ea1bTXSkK	C	P	HR	https://dubno-adm.gov.ua/	–	–
23	2018	A	Enerhodar		We provide energy	https://lnk.ua/CgpY1gEY7	C	P	S	https://gromada.en.gov.ua/	–	–
24	2018	A	Ivano-Frankivsk		A City for Living	https://www.mvk.if.ua/symbol	C	P	A	https://www.mvk.if.ua/	✓	https://iftravel.com.ua/

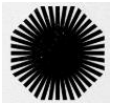
Continuation of the Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13
25	2018	A	Irpin		A City for Living	https://lnk.ua/4Lx73zFAd	C	M	CS	https://imr.gov.ua/	–	https://irpin.ua/
26	2018	A	Lutsk		A Pleasant Discovery	https://www.lutskrada.gov.ua/pages/symbols-city	C	P	A	https://www.lutskrada.gov.ua/	✓	https://www.visit-lutsk.com/
27	2018	A	Khmelnytskyi		New Every Day	https://lnk.ua/PTjxCn3K4 https://lnk.ua/uREy3ZmUj	C	P	HR	https://www.khm.gov.ua/	–	https://khmel.travel/
28	2019	A	Vinnytsia		City of Ideas	https://vinnytsia.city/design/	C	P	HR	https://www.vmr.gov.ua/	–	https://vinnytsia.city/
29	2019	A	Henichesk		A Bridge to Relaxation	https://lnk.ua/INstZm0jm https://lnk.ua/17i5fsPTC	C	P	CS	http://genich-rada.gov.ua/	–	–
30	2019	A	Kropyv-nytskyi		–	https://lnk.ua/INC6ZQLnW	C	T	A	https://www.kr-rada.gov.ua/	–	https://kroptravel.gov.ua/
31	2019	A	Nova Kakhovka		City of a Thousand Springs	https://lnk.ua/4gQKGfvkb	C	T	SP	https://novakahovka.com.ua/uk	–	–
32	2019	P	Ostroh		A City That Unites	https://lnk.ua/TKaSa8rYI	S	M	A	https://ostroh-rada.gov.ua/	–	http://ostrogtoor.com.ua/
33	2019	A	Slavuta		Everything Is in Our Hands	https://lnk.ua/sAR7UhKoC	C	P	CS	https://slavuta-mvk.gov.ua/	–	–
34	2019	P	Yavoriv		City of Good Traditions	https://brandville.com.ua/portfolio/misto-yavoriv/	C	P	SP	https://yavoriv-rada.gov.ua/	–	–
35	2020	A	Starobilsk		A City with Substance	https://starobelsk.lg.ua/kontakty/item/409-symvolika	C	P	CS	https://starobelsk.lg.ua/	✓	–

Continuation of the Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13
36	2020	A	Boryslav		It All Started with Oil	https://boryslavrada.gov.ua/tur-turystychnyi-brend-mista	C	P	SP	https://boryslavrada.gov.ua/	✓	https://tur.boryslavrada.gov.ua/
37	2020	P	Kamianka-Buzka		Cradle of Ukrainian Theatre	https://lnk.ua/tq5H435GW	C	P	CS	https://kbmr.gov.ua/	✓	–
38	2020	A	Mykolaiv		A City Riding the Wave	https://lnk.ua/4cqAHpXhE	C	P	SP	https://mkrada.gov.ua/	–	–
39	2020	A	Nizhyn		Always different	https://lnk.ua/XaOWgm7Sw	C	P	A	https://www.nizhynrada.gov.ua/	✓	–
40	2020	A	Sumy		It is important to see what is important	https://visit.sumy.ua/brandsumy/	T	T	S	https://smr.gov.ua/uk/	✓	https://visit.sumy.ua/
41	2020	A	Fastiv		City of Unity	https://lnk.ua/jsuoiFWrA	C	P	CS	http://fastiv-rada.gov.ua/	✓	–
42	2021	P	Novoyavorivsk		A Comfortable City for Growth and Victories!	https://brandville.com.ua/portfolio/misto-novoiavorivsk/	T	P	T	https://novmiskrada.gov.ua/	–	–
43	2021	A	Oleksandriya		–	https://lnk.ua/shp7YlfGf	C	M	HR	https://olexrada.gov.ua/	✓	–
44	2021	A	Uzhhorod		Uzhhorod Is Blossoming!	https://lnk.ua/GcivV4mMG	C	M	S	https://rada-uzhgorod.gov.ua/	–	https://visit-uzhhorod.itc.gov.ua/

End of Table 3

1	2	3	4	5	6	7	8	9	10	11	12	13
45	2021	A	Chornobyl		–	https://lnk.ua/QzhPguuuN	S	M	S	–	–	–
46	2022	A	Novovolynsk		Open to the New	https://lnk.ua/KgXNs8yuA	C	M	HR	https://nov-rada.gov.ua/	✓	–
47	2023	A	Zviahel		City of Bells	https://lnk.ua/fgDTe9YCV	C	T	H	https://info.nvrada.gov.ua/	✓	–
48	2023	P	Korostyshiv		City with Granite Roots	https://www.radiokor.com.ua/2023/09/15/brendmista/	C	T	T	https://korostyshiv-rada.gov.ua/	–	–
49	2024	P	Kremenchuk		A City of Strength. A City of Flint	https://kremenchuk.ocb.works/	C	T	HR	https://kremen.gov.ua/	–	–
50	2024	A	Stryi		The Flow of Development	https://lnk.ua/FJaurwLuH	C	M	N	https://stryi-rada.gov.ua/	–	https://stryi-tur.info/kontakti
51	2024	A	Chernivtsi		A Mosaic of Cultures	https://lnk.ua/FUEcHoBct https://lnk.ua/2Kffqu4h4	C	T	S	https://city.cv.ua/	✓	https://travel.chernivtsi.ua/
52	2025	A	Kamianets-Podilskyi		Kamianets Can Do What You Can Do	https://lnk.ua/UrogqU6q0	C	M	CS	https://kam-pod.gov.ua/	✓	https://kamianets.travel/ua
53	2025	A	Pivdennoukrainsk		A Mosaic of Impressions	https://lnk.ua/nFklVhn6R	C	P	CS	https://yu.mk.ua/	–	–

Source: compiled by the author.

Thus, out of 53 branded cities, 43 (81.13%) have an approved brand, while the remaining 10 cities (18.87%) have presented their brands but have not yet had them approved. All cities have created logos and have city council websites, which serve as a kind of "calling card" for the city. Almost all logos are accompanied by slogans, though there are a few instances (Dubno, Kropyvnytskyi, Oleksandriia, Chornobyl) where the brand lacks a slogan. In 24 of the 52 cities (46.15%), the city council's website mentions the city's brand, but in the majority (28 cities – 53.85%), it does not. As for tourism websites, they exist in 27 of the 52 cities (51.92%). Chornobyl is not included in these metrics because it is a city without a functioning local government and, accordingly, does not have a city council website or a tourism portal. At the same time, the city is included in the overall sample for branding analysis as a special case.

The branding of Ukrainian cities began in 2010 (*Figure 2*), with Chernihiv being the first city to receive its own brand. Brand development activity peaked in 2018 (when 8 brands were created). Overall, the period from 2017 to 2020 proved to be the most productive, with more than half of the existing brands (28 brands) created during this time. City branding in 2020 was likely linked to encouraging citizens to engage in domestic tourism, due to the pandemic and restrictions on cross-border travel. In 2022, activity declined due to the outbreak of full-scale war; however, despite this, cities continued to create their own brands, and a further 8 new city brands emerged between 2022 and 2025. In addition, in 2019, the logos of Lviv and Kryvyi Rih – which were created in 2011 and 2013 respectively – underwent a minor revamp.

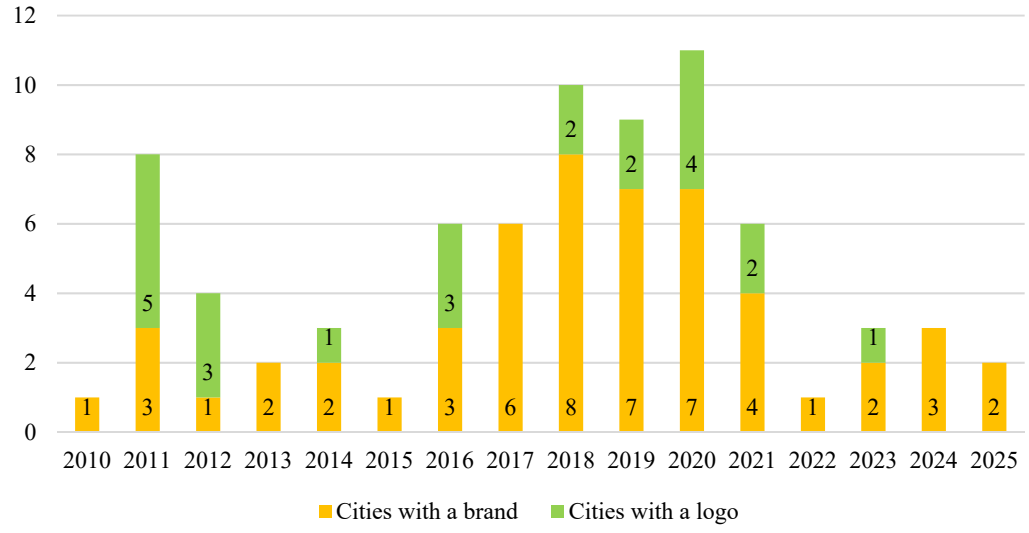


Figure 2. Chronology of the creation of Ukrainian city brands and logos

Source: compiled by the author.

As noted, only logos have been developed in 23 cities of Ukraine, and their analysis is presented in *Table 4*. Since 2014, 5 cities have been located

in temporarily occupied territories (Donetsk, Kerch, Saki, Sudak, Feodosia), because of this, their logos have not been updated, and the websites of city councils and tourism websites were not included in the study.

Of the 23 available logos – 13 (56.52%) have been approved, while10 (43.48%) have only been presented. Slogans are present in 18 cities, while 5 cities (Bogodukhiv, Izmail, Odesa, Poltava, Yaremche) have only an image of the logo. The logo is mentioned on 6 city council websites (26.09% of cities, or 33.33%, excluding the temporarily occupied territories). Tourism websites are available in 5 of the 23 cities (21.74% or 27.77%, excluding the temporarily occupied territories).

Cities began developing their own logos in 2011 (*Figure 2*) and these were primarily created by Crimean resorts. After 2011 (5 logos), the most productive years were 2020 – 4 logos, 2012 and 2016 – 3 logos were created each. In contrast, in 2013, 2015, 2017, 2022, and after 2023, no new city logos were created.

In 2022, changes were made to the logo of Izmail, which had been approved in 2020: the Ukrainian letter «*З*», which symbolizes the Danube River, changed its color from light blue to the colors of the national flag. An update to Kharkiv logo was also planned, but it remains unchanged for now. The logos of Odesa and Poltava, however, sparked a wave of criticism, yet they have not been updated to date.

Based on an analysis of the data in *Tables 3* and *4*, it was found that 28 cities use the word "city" in their slogans. Of these, 23 cities have a brand, while 5 only have a logo. It is also interesting that Irpin and Ivano-Frankivsk have the same slogan "A City for Living", and their brands were developed in 2018. In addition, Kryvyi Rih has 2 slogans: for the internal "A city spanning a lifetime" and external consumer ("Cornucopia of yours opportunities"). Uzhhorod has a full "Uzhhorod is blossoming! It blossoms in you, it blossoms in everyone" and a short "Uzhhorod is blossoming (in business, innovation, science, culture, art) " version of its slogan.

Some cities are creating full-fledged brands/logos that showcase the city in various areas (Dnipro, Kryvyi Rih, Khmelnytskyi, etc.). However, most cities focus on developing their tourism potential, so they create tourism brands/logos (Zaporizhzhia, Chornomorsk, Uzhhorod, Uman, Chernihiv, Ostroh, Volodymyr, Boryslav, Kamianka-Buzka, Kharkiv, Poltava, and others).

In total, 76 cities in Ukraine have a visual identity (logos): 53 – brands, 23 – logos only. In terms of structure, combined logos predominate (69 – 90.79%). Symbolic (4 – 5.26%) and text-based (3 – 3.95%) logos are hardly ever used. In terms of colour palette, multicoloured logos (39 – 51.32%) account for more than half of all logos, while two-colour logos двоколірні (20 – 26.32%) represent approximately half as many. Monochromatic logos (17 – 22.37%) are the least common. An analysis of the logo themes is shown in *Figure 3*.

Table 4

Logos of Ukrainian cities

№	Year of logo creation	Logo status	City	Logo	Slogan	Source of the logo image	Logo analysis			City Council website	Logo information on the City Council website	Official city tourism website
							Structure	Colour palette	Logo theme			
1	2	3	4	5	6	10	7	8	9	11	12	13
1	2011	P	Donetsk		Donetsk Loves You	https://www.radiosvoboda.org/a/2295781.html	C	M	S	TOT*		
2	2011	A	Kerch		City of Millennia	https://investigator.org.ua/ua/news-2/12307/	C	P	H	TOT		
3	2011	P	Saki		With Love and Care	https://investigator.org.ua/ua/news-2/13654/	C	P	CS	TOT		
4	2011	P	Feodosia		God-Given	https://investigator.org.ua/ua/resorts-news/9583/	C	P	H	TOT		
5	2011	P	Kharkiv		Smart city	https://lnk.ua/DbGnKoLUe	C	T	S	https://city.kharkiv.ua/	–	https://kharkiv-travel.com.ua/
6	2012	A	Berdyansk		Heart of the Azov	https://www.facebook.com/berdyansk.travel/	C	P	N	https://brd.gov.ua/	–	–

Continuation of the Table 4

1	2	3	4	5	6	10	7	8	9	11	12	13
7	2012	A	Odesa		–	https://lnk.ua/KqKSNjaff	S	M	SP	https://omr.gov.ua/	–	https://www.odesatourism.site/
8	2012	P	Sudak	ВАМСУДАК	VAMSUDAK!/ Welcome Here!	https://lnk.ua/6dmJ5MUWt	C	P	N	TOT		
9	2014	A	Zhytomyr	ЖИТОМИР	Comfortable for Living	https://zt-rada.gov.ua/?pages=361	C	P	S	https://zt-rada.gov.ua/	✓	–
10	2016	A	Kolomyia	КОЛОМИЯ місто, яке єднає	A City That Unites	https://lnk.ua/0WDULRfSk	C	P	CS	https://kolrada.gov.ua/	✓	–
11	2016	P	Poltava	ПОЛТАВА	–	https://lnk.ua/ztno4FSw0	C	T	CS	https://rada-poltava.gov.ua/	–	https://www.visitpoltava.com/uk
12	2016	A	Uman	Умань МІСТО, ДЕ ТЕБЕ ЧЕКАЮТЬ!	A City Where You Are Expected!	https://lnk.ua/QNL92uHuc	C	P	CS	https://uman-rada.gov.ua/	–	https://umantravel.com.ua/
13	2018	P	Izium	Ізюм обійми мене серцем	Embrace Me with Your Heart	https://lnk.ua/EoshHoR7s	C	P	CS	https://city-izyum.gov.ua/	–	–
14	2018	A	Morshyn	МОРШИН оздоровлює	Morshyn Heals	https://zbruc.eu/node/77141	C	T	SP	https://morshyn-rada.gov.ua/	–	–

End of Table 4

1	2	3	4	5	6	10	7	8	9	11	12	13
15	2019	P	Nadvirna	НАДВІРНА ШЛЯХ ДО КАРПАТ	The Road to the Carpathians	https://lnk.ua/9iXNkvi1R	C	M	CS	https://nadrada.gov.ua/	–	–
16	2019	A	Yaremche	ЯРЕМЧЕ	–	https://zbruc.eu/node/94425	C	M	CS	https://yaremcha-miskrada.gov.ua/	✓	–
17	2020	P	Bilhorod-Dnistrovskyi	Білгород-Дністровський Родзинка півдня	The Raisin of the South/ The Gem of the South	https://lnk.ua/AJKo6N5uw/	C	P	N	https://bilgorod-d.gov.ua/ https://bdmr.gov.ua/	–	–
18	2020	A	Volodymyr	Володимир місто твоєї історії	City of Your History	https://volodymyrrada.gov.ua/pro-misto/symvolika-mista/	C	T	CS	https://volodymyrrada.gov.ua/	✓	https://volodymyr.travel/
19	2020/2022	A	Izmail	izmail	–	https://lnk.ua/rnf2TI91j	C	T	N	https://izmail-mr.od.gov.ua	–	–
20	2020	P	Pustomyty	ПУСТОМИТИ МІСТО МОЖЛИВОСТЕЙ	City of Opportunities	https://surl.li/qifdqs	C	P	CS	https://pustomyty-gromada.gov.ua/	–	–
21	2021	A	Berdychiv	БЕРДИЧІВ Час відчути	Time to Feel	https://surl.li/coxpsh	C	P	G	https://berdychiv-rada.gov.ua	✓	–
22	2021	A	Bohodukhiv	БОГОДУХІВ	–	https://lnk.ua/ZohHlwz1z	C	P	S	https://bogoduhivska-gromada.gov.ua/	✓	–
23	2023	A	Chortkiv	ЧОРТКІВ тут ти вдома	You Are Home Here	https://www.instagram.com/p/Cww038TtViZ/	S	M	A	https://www.chortkivmr.gov.ua/	–	–

* TOT – Temporarily Occupied Territory

Source: compiled by the author.

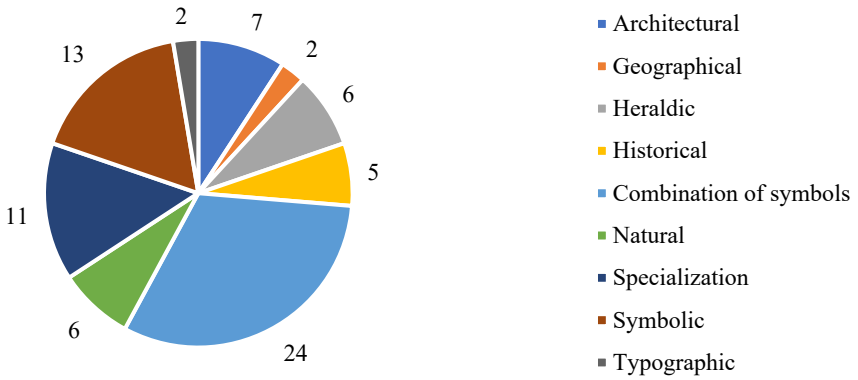


Figure 3. Quantitative breakdown of city logos by theme

Source: compiled by the author.

According to the results of a study of city brand books and a visual analysis, it was found that:

- 7 cities have architectural logos: Ivano-Frankivsk (a projection of the City Hall), Kropyvnytskyi (a projection of St. Elizabeth's Fortress), Lutsk (a key and the Entrance Tower of Lutsk Castle), Lviv (five towers from the city center: the bell tower of the Armenian Cathedral, the Korniakt Tower, the City Hall, the tower of the Latin Cathedral, and the bell tower of the Bernardine Monastery), Nizhyn (a logo in the shape of a church), Ostroh (the Tatar Tower), Chortkiv (the castle, the old and new city halls, and the Dominican Church).
- 2 cities have geographical logos: Berdychiv (the city's actual landscape, using the "golden ratio" approach) and Bila Tserkva (a map of the city).
- 6 city logos have a heraldic basis: Kremenchuk (based on the city's coat of arms but rendered in a minimalist style), Novovolynsk (inspired by the visual appearance of the city's coat of arms, with an artistic transition from a chestnut blossom to the shape of a cursor (arrow)), Oleksandriia (a minimalist depiction of the coat of arms, inspired by associations with nature), Vinnytsia (modernized coat of arms), Khmelnytskyi (the logo preserves the concept of the coat of arms, with arrows symbolizing the city's focus on development and evolution), Dubno (based on the coat of arms).
- 5 logos are formed on the basis of the historical past of the cities: Zviahel (historical symbols: visualization of the bell placed on the fortress), Kerch (the columns of Panticapaeum, the sun, and the Ukrainian letter "E" "E" which resembles the Kerch Strait between the Black Sea and the Sea of Azov), Mala Vyska (a plane with historical significance (the first airplane designed by Ukrainian engineer Oleksandr Kudashev and the "Vys" aviation festival), Feodosia (associations with Greece, winemaking, myths, and Gods), Kherson (using images of the Scythian-Sarmatian period and the Fibonacci's "golden spiral").

• 24 cities have logos consisting of a combination of symbols: Volodymyr (the Ukrainian letter «*B*» ("V"), a crucifixion and an ornament), Henichesk (rhombuses containing elements that highlight the city's unique features: the sea, an anchor, a bird, a lighthouse, and a fish), Dnipro (a combination of a wave (representing the Dnipro River) and a shield), Zaporizhzhia (lines symbolizing 7 paths (or tourist routes) and a six-pointed star), Izium (the logo combines two types of symbols: 1) bunches of grapes and 2) the meanders of the Siverskyi Donets River (purple circles) with endless forests (green patterns)), Irpin (a human figure in the shape of a tree with leaves inscribed within a rhombus, which is a symbol of fertility), Kamianets-Podilskyi (the square (a symbol of the rock upon which Kamianets stands and from which it arose) and the five rays, which symbolize the target audiences the brand is focused on: residents, tourists, entrepreneurs, young people, and the municipality), Kamianka-Buzka (featuring the image of a cat and theatrical facial expressions), Kyiv (a "drop" representing the Dnipro River; a "chestnut" symbolizing the city-as-a-park; a "dome" reflecting the abundance of churches; a "heart" denoting a comfortable, welcoming city), Kolomyia (a symbol consisting of three basic components: a star, which is an archaic spiritual symbol and the central element of the Kolomyia pysanka, a circle (an ancient symbol synonymous with the city), and eight arrow-like sectors), Melitopol (a combination of honeycombs and machine gears, reminiscent of a rushing stream and the city's name, whose three letters form an image of cherries), Nadvirna (the Ukrainian letter «*H*» ("N")), a spruce branch, elements of Hutsul ornamentation, tracks left by skis, a bicycle, and a car, as well as the reflection of a railroad track), Pivdennoukrainsk (a heart combined with rich Cossack symbolism: a falcon, sabers, the letter "G" representing the island of Hard, the Rocky Church, and Berehynia), Poltava (a bow with a downward-pointing arrow, framed by the city's emerald greenery, topped by three flowers symbolizing the three historical hills of ancient Poltava: the central one being Ivanova Hora, the one on the left Monastyrska, and the one on the right Instytutska), Pustomyty (square – city, arrow – movement), Rivne ("silver" gate, an eight-pointed star (referencing embroidery), visual feature (parks), crossroads (city at a crossroads)), Saki (a stylized four-leaf clover, where each leaf has symbolic meaning: blue – the sea, green – parks and clean air, pink in the shape of a heart – the love and hospitality of the townspeople, brown – the resort's therapeutic mud), Slavuta (two Ukrainian letter «*C*» ("S") shapes resembling hands that form the letter "S"; one hand features three green leaves (representing the city's nature) while the other holds three water droplets (symbolizing the city's waterways)), Slavutych (the letter "*I*" (ideas, innovations, intellect, etc.), an arrow, hands surrounded by buildings, a road, arches), Starobilsk (a circle, the Ukrainian letter «*C*» ("S") framing the city like a dome, and figures symbolizing architectural landmarks, the Aidar River, parks with public squares, cycling culture, etc.), Uman (three sectors

symbolizing a Cossack with a spear, the "Sofiyivka" National Dendrological Park, nature, and youth), Fastiv (the Ukrainian letter «*Ф*» ("F"), a tree, a heart, and a knot), Chernihiv (a tangled ball of thread incorporating images of a church, a ghost, a sword, and a river), Yaremche (mountain silhouettes and traditional motifs characteristic of Hutsul culture).

- 6 logos are based on natural motifs: Berdiansk (a heart containing waves that represent the sky, the sea, beaches, and greenery), Bilhorod-Dnistrovskyi (a bunch of grapes and a sea wave), Izmail (the Danube River and the sun), Stryi (a rushing river current), Sudak (a frog – inspired by Mount "Bakatash", which translates as "Frog Rock"), Ternopil (the Ukrainian letter "T" composed of three green cubes symbolizing the city's parks, along with blue waves representing the local Pond).
- 11 logos reflect the specialization of the cities: Boryslav (a drop of oil); Boryspil (an airplane taking off into the sky), Drohobych (the logo consists of a salt block, Yuriy Kotermak's astrolabe and the Ukrainian letter «*Д*» (D); with the composition rounded off by a smile), Kalush (three salt blocks on a red background symbolize salt production as the main industry), Mariupol (an anchor in a stream of molten steel pouring from a metallurgical ladle), Mykolaiv (the Ukrainian letter "M" formed by two fully billowing sails riding the waves, and a flag fluttering above it, indicating the direction of the tailwind), Myrhorod (the healing properties of the world-famous Myrhorod mineral water), Morshyn (mineral water (balneological resort), Nova Kakhovka (wave-like strokes symbolizing the Kakhovka Hydroelectric Power Plant), Odesa (a heart-shaped anchor), Yavoriv (a traditional Yavoriv toy).
- 13 cities have symbolic logos: Bohodukhiv (a fireworks symbol and an image of a blackthorn tree), Donetsk (the letter "D", which resembles: a diamond, a piece of coal, and a rose), Energodar (a shape resembling the orbits of atoms under a microscope, which also echoes the ethnic symbol of the Ukrainian vyshyvanka), Zhytomyr (the Ukrainian letter «*Ж*» ("Zh") composed of geometric elements typical of Polissia folk ornamentation: rhombuses, crosses, and stripes), Zhovkva (a logo consisting of six elements that collectively form the Ukrainian letter «*Ж*» ("Zh"). Each element represents religion, landscape, education, architecture, community, and culture), Kryvyi Rih (a horn formed from a mosaic of ore strata: a "horn of plenty" symbolizing the confluence of the Inhulets and Saksahan Rivers and the Cossack figure "Rih" with colors representing ore deposits and the smelting process), Pavlohrad (the logo has no official meaning, but visually it resembles a stylized Ukrainian letter «*П*» ("P") symbolizing growth and movement), Sumy (the letters symbolize well-known facts about the city (the gazebo, the "sotnia", roses, etc.) while the dots between the letters represent the interesting sights worth seeing (architecture, landmarks)), Uzhhorod (the Ukrainian letter «*У*» ("U") resembling a sakura blossom), Kharkiv (a green shape that hat resembles the Ukrainian letter «*Х*» ("Kh") from the outside),

Chernivtsi (a pattern from a traditional embroidered shirt (vyshyvanka)), Chornobyl (the surface of the fourth reactor), Chornomorsk (the Ukrainian letter «*Ч*» ("Ch") with a tail shaped like a hook or a fish's tail, symbolizing a maritime theme).

- 2 cities have typographic (text-based) logos: Korostyshiv (an unusual combination of letters) and Novoyavorivsk (a purely typographic logo, since the city does not have a symbol that is particularly well-known or distinctive).

Based on the data presented in *Figure 4*, it can be noted that only some Ukrainian cities (11.50%) have their own brands, and these have been officially approved in only 43 cities (81.13% of the cities with brands / 9.33% of the total number of cities). Additionally, 23 cities (4.99%) have logos, of which only 13 (56.52% of the cities with logos / 2.82% of the total number of cities) have been officially approved.

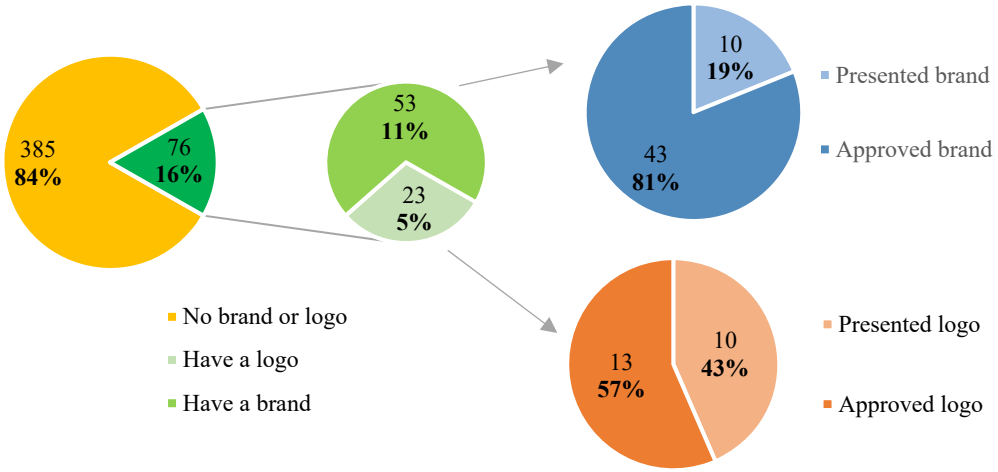


Figure 4. Analysis of Ukrainian cities for the presence of a logo/brand

Source: compiled by the author.

Thus, this study has provided a comprehensive overview of the level of city branding development in Ukraine and identified cities that require further brand implementation.

Conclusions

The scientific hypothesis underlying the study – that only some Ukrainian cities have an officially established brand, while a significant number of cities do not use branding as a tool for territorial development and positioning – has been confirmed. Currently, 384 cities (83%) do not have their own visual identity, which presents significant potential for the development of territorial branding in Ukraine.

As a result of the research, the following examined the administrative-territorial division of Ukraine, analyzed official city council websites, presented the visual identities of cities, systematized data on the presence of

Ukrainian city brands and assessed the current state of their development. It has been determined that city branding in Ukraine is at an insufficiently developed stage: most cities do not have clearly defined brands, while some use individual elements of brand attributes without a systematic or strategic approach.

The scientific novelty of this study lies in the systematization of information regarding the existence of brands for Ukrainian cities and the definition of their visual identities.

The practical significance of this study lies in the ability of local governments to use its findings to analyze the competitive environment, identify best practices, and determine areas for improving existing brands. This will help prevent the duplication of existing visual and conceptual solutions and promote more coherent and competitive city brand development.

This article is part of a comprehensive analysis of the state of territorial branding in Ukraine. Therefore, future research should focus on analyzing the branding of villages, settlements, territorial communities and regions of Ukraine. In addition, relevant areas for future research include identifying the impact of branding on territorial competitiveness and socio-economic development, as well as developing methodologies for assessing the effectiveness of territorial branding.

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COMPUTER VISION IN IMPROVING THE EFFECTIVENESS OF DIGITAL ADVERTISING IN RETAIL

Modern retail is in a state of permanent digital transformation. A key driver of these changes is the implementation of artificial intelligence technologies, and specifically computer vision (CV), which allows machine algorithms to interpret and understand the visual world significantly faster and more accurately than human vision. For marketing management, this signifies a transition from the intuitive management of digital advertising impacts to strategies based on objective visual data in real time. This necessitated a multidisciplinary study aimed at substantiating the role and determining the directions of using computer vision technologies to improve the effectiveness of digital advertising in the offline and online environments of retail enterprises. The study is based on the hypothesis that the integration of computer vision systems to influence the target audience in real time and correspondingly adapt advertising content will significantly increase key engagement metrics and, consequently, conversion from digital advertising compared to traditional non-targeted approaches. The hypothesis is substantiated using the methods of theoretical and conceptual research: systemic-structural analysis, multidisciplinary synthesis, and logical generalization to formulate the study's conclusions. The article considers the stages of implementation and the possibilities of using computer vision technologies in retail. It is noted that in addition to technological advantages, the

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КОМП'ЮТЕРНИЙ ЗІР У ПІДВИЩЕННІ ЕФЕКТИВНОСТІ ЦИФРОВОЇ РЕКЛАМИ В РИТЕЙЛІ

Сучасний ритейл перебуває у стані перманентної цифрової трансформації. Ключовим драйвером цих змін є впровадження технологій штучного інтелекту (ШІ) і, зокрема, комп'ютерного зору (CV), що дозволяє машинним алгоритмам інтерпретувати та розуміти візуальний світ значно швидше та точніше за людського зору. Для маркетинг-менеджменту це означає перехід від інтуїтивного управління цифровими рекламними впливами до стратегій, що базуються на об'єктивних візуальних даних у реальному часі. Це обумовило необхідність проведення міждисциплінарного дослідження, метою якого є обґрунтування ролі та визначення напрямів використання технологій комп'ютерного зору для підвищення ефективності цифрової реклами в офлайн- та онлайн-середовищах підприємств роздрібної торгівлі. В основу дослідження покладено гіпотезу, що інтеграція систем комп'ютерного зору для впливу на цільову аудиторію в режимі реального часу та відповідної адаптації рекламного контенту дозволить значно підвищити ключові показники залученості та, як наслідок, конверсію від цифрової реклами порівняно з традиційними нетаргетованими підходами. У ході дослідження використано методи теоретико-концептуального дослідження: системно-структурного аналізу, міждисциплінарного синтезу та логічного узагальнення для формулювання висновків. Розглянуто етапи впровадження й можливості використання технологій комп'ютерного зору в ритейлі. Зазначено, що крім

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implementation of CV technologies in Ukrainian retail involves two other important factors driven by the war: physical security with remote management, and the compensation of labor resources. The omnichannel dimension of computer vision integration into digital retail advertising is investigated. A comparative characteristic of using CV technologies in offline and online retail environments is provided. The impact of computer vision on the real-time optimization of digital advertising is determined. The specifics of offline and online optimization of advertising impact using CV technologies are described. It is emphasized that a synergistic result in improving the effectiveness of digital advertising is achieved subject to the seamless integration of online and offline computer vision tools into a single omnichannel ecosystem. The conclusions state that the increased efficiency of digital advertising is achieved through the Phygital integration of CV technologies. The combination of a consumer's online preferences with their objective reactions on the sales floor forms an end-to-end behavioral profile, transforming disparate advertising broadcasts into continuous, hyper-personalized interaction.

Keywords: digital advertising, marketing-management, computer vision, Phygital integration, digital behavior, digital trust, advertising strategies, behavioral economics, retail.

JEL Classification: M31, M37, L81.

технологічних переваг, впровадження CV-технологій в українському ритейлі має ще два важливих фактори, зумовлені війною: зокрема, фізична безпека, віддалене управління та компенсація трудових ресурсів. Досліджено омніканальний вимір інтеграції комп'ютерного зору в цифрову рекламу ритейлу. Надано порівняльну характеристику використання CV-технологій в офлайн- та онлайн-середовищах роздрібної торгівлі. Визначено вплив комп'ютерного зору на оптимізацію цифрової реклами в реальному часі. Описано специфіку офлайн- та онлайн-оптимізації рекламного впливу за допомогою CV-технологій. Наголошено, що синергетичний результат у підвищенні ефективності цифрової реклами досягається за умови безшовної інтеграції онлайн- та офлайн-інструментів CV в єдину омніканальну екосистему. У висновках зазначено, що підвищення ефективності цифрової реклами досягається завдяки Phygital-інтеграції CV-технологій. Об'єднання онлайн-преференцій споживача з його об'єктивними реакціями в торговельному залі формує наскрізний поведінковий профіль, перетворюючи розрізнені рекламні трансляції на безперервну гіперперсоналізовану взаємодію.

Ключові слова: цифрова реклама, маркетинг-менеджмент, комп'ютерний зір, *Phygital*-інтеграція, цифрова поведінка, цифрова довіра, рекламні стратегії, поведінкова економіка, ритейл.

Introduction

Modern retail businesses spend substantial budgets on digital advertising but lack objective metrics to measure its effectiveness. Traditional methods, such as surveys, reviews, and complaints, are subjective, delayed, and not always relevant. One of the key communication channels directly at points of sale is digital advertising displayed on Digital Signage screens. However, such content is static and broadcast according to the same scenario for the entire audience. This results in low consumer engagement and makes it impossible to objectively assess the return on investment in these advertising tools. This creates a "blind spot" in customer experience assessment, as shoppers ignore advertising messages for various reasons. A study by Bain & Company (2024) confirmed that 40% of consumers consider the advertisements they see irrelevant, highlighting the need to use computer vision and AI-driven personalization to improve the effectiveness of advertising messages.

The application of computer vision (CV) in retail has attracted the attention of numerous researchers. The significance of this technology was substantiated by Gopinath (2024) in the context of CV's impact on operational efficiency, customer experience, and marketing performance. The researcher emphasized that computer vision enables more accurate advertising targeting and enhances consumer engagement, thereby stimulating conversions and

brand loyalty. Chen and Thompson (2024) argue that CV and artificial intelligence will shape the future of customer interfaces by transforming physical retail spaces into interactive environments.

The global CV technology market is experiencing rapid growth. According to Fortune Business Insights (2026, September 14), its value was estimated at USD 17.84 billion in 2024 and USD 20.75 billion in 2025. The market is projected to grow from USD 24.14 billion in 2026 to USD 72.8 billion by 2034, demonstrating a compound annual growth rate (CAGR) of 14.80%. In the retail sector, the growth in revenue generated by the CV industry has been driven by the increasingly fundamental role of CV in retail automation and the integration of generative artificial intelligence capabilities to expand product portfolios and improve customer experience.

Thus, scientific publications and statistical analyses focus on examining the transformative role of CV in improving retail analytics and consumer experience. Researchers note that computer vision enables real-time analysis of customer behaviour, providing retailers with information on foot traffic, product interactions, movement patterns, dwell times in different areas, and the emotional atmosphere of the retail space. By using surveillance camera data and advanced tracking algorithms, retailers can optimize store layouts, strategically position popular products and advertising displays, and make effective use of high-traffic areas. This will not only enhance customer satisfaction but also increase sales and improve operational efficiency (Nandhini et al., 2024).

Ukrainian researchers are actively investigating related issues concerning the implementation of innovative algorithms in advertising. In particular, the use of Machine Learning algorithms to improve brand management in the online environment is comprehensively examined in the works of Iankovets et al. (2025). The application of ML technologies for dynamic pricing and digital marketing optimization is explored by Ponomarenko et al. (2025). In addition to the technological dimension of communications, domestic scholars pay considerable attention to the ethical aspects of advertising and brand management. For example, in their study of eco-branding among companies in the FMCG sector, Bondarenko and Siazin (2024) emphasize the importance of transparency and warn of the reputational risks associated with unethical manipulation (greenwashing).

At the same time, the application of computer vision in the context of digital advertising in retail remains insufficiently addressed in the scientific literature. Despite the existence of comprehensive studies on the implementation of AI technologies and ethical communications, the application of computer vision (CV) as a tool for optimizing digital advertising requires further investigation. This highlights a research and practical gap in the study of CV tools, the application of which could transform digital advertising into a measurable and adaptive communication channel.

The purpose of this article is to substantiate the role of computer vision technologies and identify areas for their application to improve the effectiveness of digital advertising by retail businesses in both offline and online environments.

The study is based on the hypothesis that integrating computer vision systems to engage target audiences in real time and adapt advertising content accordingly will significantly improve key engagement metrics (Attention Rate and Engagement Rate) and, consequently, increase conversions from digital advertising compared with traditional non-targeted approaches. Theoretical and conceptual research methods were employed, including systems and structural analysis, interdisciplinary synthesis, and logical generalization, to formulate the conclusions.

The main body of the article is structurally divided into three sections. The first examines the stages of implementation and the potential applications of computer vision technologies in retail. It is noted that, in addition to technological advantages, the implementation of CV technologies in Ukrainian retail is influenced by two other important factors arising from the war: physical security, remote management, and the compensation for workforce shortages. The second section focuses on the omnichannel dimension of integrating computer vision into digital retail advertising. It provides a comparative overview of the use of CV technologies across different retail environments. The third section characterizes the impact of computer vision on real-time digital advertising optimization. It describes the specific features of optimizing advertising impact in offline and online environments using CV technologies. It is emphasized that a synergistic improvement in digital advertising effectiveness can be achieved through the seamless integration of online and offline computer vision tools into a unified omnichannel ecosystem.

The informational, theoretical, and methodological basis of the study comprised analytical reports by international and national organizations, marketing research, monographs, and scientific publications by Ukrainian and international authors examining the application of computer vision in digital advertising by retail businesses.

1. Evolution of computer vision applications in retail

The modern retail industry is undergoing continuous digital transformation. One of the key drivers of these changes is computer vision, a field of artificial intelligence that enables machine algorithms to interpret and understand the visual world at a level comparable to human vision, and often much faster and more accurately. For marketing management, this means a shift from intuitive consumer behaviour management to strategies based on objective visual data collected in real time.

The use of machine vision in retail is not an entirely new phenomenon; however, its intended purpose has undergone continuous changes (Grewal, Noble et al., 2020). At the first stage (beginning in the early 2010s), the primary purpose of computer vision was operational security, with CV systems viewed exclusively as tools for loss prevention (Loss Prevention). Algorithms were used to detect suspicious behaviour near checkout counters and monitor shoplifting. This technology was static and did not involve interaction with consumers.

At the second stage (from the mid-2010s), computer vision was also used for inventory management and merchandising. As computing power increased, cameras began scanning shelves to detect out-of-stock items and place orders automatically. During the same period, the first CV tools for generating "heat maps" (visual representations of consumer activity) were developed. These enabled store managers and marketers to analyse shoppers' movement patterns throughout the store and, accordingly, organize store zones, arrange product displays, design window displays, and position advertising materials (Grewal, Noble et al., 2020).

At the current stage, computer vision technologies are shifting towards customer experience (CX) management. The integration of advertising panels with cameras has become possible, transforming them into smart displays capable of recognizing the audience in front of the screen and instantly assessing its reaction to the creative content. The potential applications of CV technologies and the transition of retail from basic operational automation to cognitive marketing management are presented in *Table 1*.

Table 1

Applications of computer vision technologies in retail

Application area	Description of the technological solution	Business impact / KPI
Inventory Management Optimization (NVIDIA, 2022)	Automated shelf scanning and product identification to detect out-of-stock situations	Preventing lost revenue due to empty shelves, timely staff alerts, and maintaining customer loyalty
Consumer Behaviour Analysis and Merchandising (Gartner, 2023)	Generating heat maps, analysing hotspots, identifying demographic characteristics, and tracking dwell time in the store and at specific locations	Optimizing product placement and improving the effectiveness of "golden shelves" based on actual data rather than assumptions
Autonomous Checkouts (Wankhede et al., 2018)	Tracking items picked up by shoppers using a combination of sensors and CV algorithms (the Amazon Go model)	Eliminating queues, improving Customer Experience (CX), reducing operational costs, and minimizing delays during checkout
Loss Prevention (Intel, 2024)	Real-time detection of suspicious behaviour and monitoring of missed scans at self-checkout counters	Minimizing theft (shrinkage) without the need to deploy excessive numbers of security personnel
Digital Advertising: Emotion Counting and Analysis (Affective Computing) (Picard, 2003)	Recognizing and recording visitors' emotions (emotion counters) near digital displays to assess micro-expressions (joy, confusion) at the moment of contact with an advertisement	Assessing emotional responses to creative content in real time and dynamically adapting content to overcome "banner blindness"
Digital Advertising: Pose Estimation and Eye Tracking (Redmon et al., 2016; Grewal et al., 2020)	Tracking gaze direction and body movements (leaning towards the screen, stopping) using high-performance architectures for rapid processing and inference	Generating visual heat maps of screens and accurately measuring shoppers' physical engagement with interactive advertising displays

Source: compiled based on (NVIDIA, 2022; Gartner, 2023; Wankhede et al., 2018; Intel, 2024; Picard, 2003; Redmon et al., 2016; Grewal, Noble et al., 2020).

In addition to technological advantages, the implementation of CV technologies in Ukrainian retail is influenced by two other important factors arising from the war. First, physical security and remote management. Due to persistent threats, air raid alerts, and restrictions on movement, retail chain managers need tools that allow them to monitor store conditions and service quality in real time without being physically present. CV systems can automatically detect smoke, unattended objects, or unauthorized access during curfew hours. Second, workforce compensation. When the number of employees in a store is reduced for objective reasons, some routine operational tasks can be delegated to computer vision (CV) technologies, including queue monitoring, shelf stock control, and verification of price tag accuracy. This allows existing employees to focus on customer service rather than repetitive manual tasks (RAU, 2023).

2. The omnichannel dimension of integrating computer vision into digital retail advertising

The transition of retail to omnichannel and hybrid business models has changed the architecture of advertising communications and, consequently, consumer responses to them (Gopinath, 2025). Digital advertising in retail is no longer limited to users' personal device screens; it extends CV technologies into the physical space of retail premises through interactive Digital Signage panels, smart mirrors and shop windows, and digital advertising displays (Chen & Thompson, 2024). Within this new paradigm, computer vision helps transform advertising delivery from a static process into a dynamically managed channel of interaction.

At the same time, the mechanisms for integrating CV technologies vary considerably depending on the environment in which digital advertising is delivered. In the online environment (e-commerce and mobile retail), computer vision optimizes advertising by analysing users' visual preferences. Algorithms recognize images with which customers have interacted, analyse user-generated content (UGC), and automatically select personalized advertising banners or videos based on visual search (Chen & Thompson, 2024). Engagement metrics are recorded through the interface, including video completion rates, repeat views, pauses, swipe speed, clicks, click-throughs, and saves. The CV system also continuously tests users by presenting videos from other subject areas (for example, 80% familiar content and 20% new content) to expand their "digital profile" and retain their attention, creating what is known as a dopamine loop.

In the offline environment of a retail store, computer vision is integrated directly into digital advertising structures, which use electronic screens, televisions, video walls, or media façades to display advertisements (Digital

Signage). Instead of displaying videos in a traditional repetitive cycle, a camera embedded in an advertising panel analyses the flow of shoppers in front of the screen and instantly adapts the advertising message to the actual audience (Gopinath, 2025). The system captures genuine emotions that cannot be faked, providing businesses with the most honest feedback possible, as it occurs before customers have had time to rationalize their reactions. In addition, cameras can record the influence of sales consultants on shoppers' moods, their reactions to shop windows and product displays, and the impact of promotional campaigns on the emotional atmosphere in the store. They can also track how customers' moods change along their shopping journey and identify the stages at which interest increases or declines. The CV system does not identify individuals or store facial images; it only analyses emotions in real time and converts them into statistical indicators. This is consistent with the requirements of the GDPR and Ukrainian legislation, as personal customer data are not collected.

A comparative analysis of the use of CV to improve digital advertising effectiveness across different retail environments is presented in *Table 2*.

Table 2

Comparative analysis of computer vision applications in online and offline digital advertising

Comparison criterion	Online digital advertising	Offline digital advertising
Method of CV Integration	Integration into recommendation algorithms used by websites and applications	Embedding CV sensors in advertising displays and shelves
Advertising Content Management	Automatic selection of visual banners based on search history	Real-time generation or switching of video advertisements depending on audience reactions
Advertising Effectiveness Metrics	CTR (Click-Through Rate) measures the percentage of users who click on an advertisement or link after seeing it. Page depth indicates the number of website pages viewed by a visitor during a session	Attention Rate measures the degree to which consumers focus on specific content or an advertisement. Dwell time measures how long a viewer's gaze remains fixed on an advertisement
Effectiveness	Optimizing customer acquisition costs (CPC) and website conversion rates	Overcoming "banner blindness" at the point of sale

Source: (Gopinath, 2025; Chen & Thompson, 2024).

Thus, while CV technologies in the online environment focus on improving the accuracy of visual recommendations, in the offline environment, computer vision addresses the "blind spot" of in-store advertising (Chen & Thompson, 2024). It transforms an ordinary advertising screen into an interactive analytical station capable of measuring shoppers' physiological responses and translating them into tangible outcomes: emotional connections, purchases, loyalty, and recommendations. This makes it possible to proceed to a detailed analysis of specific technological methods that enable such optimization during

advertising display and help offline stores compete with online platforms (Grewal, Hulland et al., 2020).

3. Computer vision in real-time advertising optimization

For digital advertising in retail to become an effective, measurable, and manageable communication channel, CV technologies must be deployed in a way that integrates them with the concepts of behavioural economics and enables their adaptive implementation in both e-commerce and the physical space of retail stores (Chen & Thompson, 2024; Gopinath, 2025).

In internet marketing and mobile applications, computer vision serves as a tool for intelligent hyper-personalization that anticipates users' needs (Bain & Company, 2024). The synergy between CV technologies and other machine learning algorithms significantly expands retailers' capabilities. It enables not only the adaptation of visual advertising content for brand management (Iankovets et al., 2025), but also the simultaneous adjustment of prices dynamically in real time according to demand and customer profiles (Ponomarenko et al., 2025). Thus, the real-time optimization of online advertising relies on several key algorithms: semantic analysis of visual content and identification of audience visual preferences, recognition of user-generated content (UGC) for native targeting, visual search technologies, and AR triggers (*Table 3*).

Table 3

Specifics of online advertising impact optimization using CV technologies

Optimization area	CV technologies	Real-time mechanism	Marketing outcome / KPI
Semantic Analysis of Visual Preferences	Neural network analysis of images and videos (Image Recognition)	Scanning and tagging the characteristics of content viewed by the user during a session. Adapting dynamic banners to these characteristics	Hyper-personalization of content delivery, increased advertising relevance, and a higher click-through rate (CTR)
Native Targeting of User Content	Object recognition in User-Generated Content (UGC)	Identifying brand elements or related products in customer-uploaded photographs. Generating seamless advertising offers	Native integration of offers into the platform's visual context and reduced advertising irritation
Shortening the Path to Purchase	Visual Search and AR triggers	Launching an advertising offer for a specific, related, or complementary product when the user activates the camera to search for an item or try it on using AR	Minimizing barriers between desire and purchase, faster conversion, and an increase in impulse purchases

Source: (Bain & Company, 2024; Chen & Thompson, 2024).

In the physical store environment, the assessment and adjustment of advertising impact directly during content playback is based on the

analysis of the following components: gaze direction, emotional response, consumers' physical engagement, safety, and privacy (*Table 4*).

Table 4

CV technologies for offline advertising content optimization

Optimization Area	CV Technologies / Algorithm	Real-Time Mechanism	Marketing Outcome / KPI
Gaze Direction Analysis	Offline eye tracking (Gaze Tracking)	Tracking visitors' pupil movements in front of Digital Signage panels. Generating dynamic heat maps of advertising frames	Accurate measurement of the Attention Rate. Adjusting video duration and layout composition (logo visibility, CTA – call-to-action text or button)
Assessment of Psychological Impact	Emotional Response Recognition (Affective Computing)	Analysing facial micro-expressions (joy, indifference, confusion). Instantly switching ineffective creative content to an alternative through algorithmic processing	Overcoming "banner blindness" and maximizing the level of emotional engagement (Engagement Rate)
Measurement of Physical Engagement	Pose and Motion Detection (Pose Estimation / YOLO)	High-speed detection of movement patterns: leaning forward, slowing down, and reaching towards an advertised product in front of a screen	Objective measurement of Dwell time. Establishing a direct correlation between advertising exposure and conversion
Safety and Privacy	Edge Computing	Local processing of the video stream by the screen's processor without storing facial images; instant conversion of video into anonymous metadata	Compliance with GDPR requirements, removal of ethical barriers, and development of consumer trust in digital technologies

Source: (Chen & Thompson, 2024; Grewal, Noble et al., 2020; Picard, 2003; Redmon et al., 2016).

An important prerequisite for effective offline advertising is the use of an Edge Computing architecture. The video stream is processed locally by the advertising display's processor, instantly transforming the visual feed into anonymized digital metrics without storing facial images. This eliminates ethical barriers, enables advertising targeting without violating consumer privacy, and increases their level of digital trust, which is a pressing issue today. As researchers in ethical marketing (Bondarenko & Siazin, 2024) rightly point out, companies' use of manipulative and unethical practices in eco-advertising leads to a loss of loyalty among target audiences. Therefore, the use of Edge Computing technologies that guarantee anonymization and personal data protection is a prerequisite for ethical and socially responsible marketing management.

Thus, the integration of computer vision technologies creates a continuous cycle of digital advertising optimization in both the virtual and

physical retail environments. Instead of relying on delayed analysis based on inaccurate assumptions, marketing management gains a tool for adapting content in real time, maximizing engagement metrics and encouraging consumers to take conversion-oriented actions. Genuine synergistic improvements in digital advertising effectiveness are achieved through the seamless integration of online and offline computer vision tools into a unified omnichannel ecosystem. When consumers' visual footprints and preferences from e-commerce platforms are algorithmically combined with data on their actual responses to Digital Signage screens in physical stores, retailers obtain a comprehensive behavioural profile. This Phygital integration of CV technologies ultimately transforms digital advertising from a set of disconnected marketing broadcasts into a continuous, hyper-personalized, and measurable dialogue with consumers at every touchpoint.

Conclusions

The study substantiates the role of computer vision (CV) technologies in digital advertising for retail businesses and identifies the main areas of their application in online and offline environments.

It is noted that in the online environment (e-commerce and mobile applications), CV technologies serve as a tool for intelligent hyper-personalization. Semantic analysis of visual preferences, native targeting based on user-generated content (UGC), and visual search make it possible to increase advertising relevance, improve the click-through rate (CTR), and minimize barriers between desire and purchase.

It is established that, in the offline environment, integrating CV sensors into Digital Signage panels overcomes the effect of "banner blindness" by instantly adapting video advertisements to audience reactions.

It is substantiated that the use of eye-tracking technologies (Gaze Tracking), emotional response recognition (Affective Computing), and pose detection (Pose Estimation) converts consumers' physiological responses into precise Attention Rate and dwell time metrics, establishing a direct correlation between advertising exposure and conversion actions. It is determined that processing video streams using an Edge Computing architecture makes it possible to transform visual data into anonymized metadata without storing facial images, thereby ensuring compliance with GDPR requirements, eliminating ethical barriers, and building consumer trust in digital technologies. It is emphasized that synergistic improvements in digital advertising effectiveness are achieved through the phygital integration of CV technologies. The seamless combination of consumers' online preferences with their actual responses in the store creates a comprehensive behavioural profile, transforming disconnected advertising broadcasts into continuous, hyper-personalized interactions.

The results obtained confirm the proposed hypothesis that integrating computer vision systems to influence target audiences in real time and adapt advertising content accordingly will significantly improve

key engagement metrics and, consequently, increase conversions from digital advertising compared with traditional approaches.

Given the dynamic development of artificial intelligence algorithms and the ongoing transformation of the retail environment, promising areas for further research include an in-depth study of algorithms for constructing an omnichannel consumer "digital profile" and the development of a methodology for assessing the economic effectiveness of implementing end-to-end phygital advertising strategies in the domestic retail sector. In the context of current security and energy challenges, research into the technical and economic feasibility of deploying Edge Computing infrastructure for advertising displays across retail chains will also be important.

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