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ECONOMIC GROWTH DRIVERS: EMPIRICAL FINDINGS FOR DEVELOPING EUROPEAN COUNTRIES

Background. *The relevance of this article lies in the persistent importance of economic growth in developing economies as a central subject of modern economic research. The growing integration of global markets and rapid technological change have significantly influenced the pace and structure of development across countries. Identifying the fundamental drivers of growth is essential for shaping policies that ensure long-term stability and sustainable progress. The experience of countries that have successfully transitioned from developing to advanced status offers valuable empirical evidence. Examining these cases makes it possible to determine the most significant factors contributing to economic growth. In this context, the study of growth drivers in developing European economies acquires particular importance for understanding their prospects for accelerated and sustainable development.*

Methods. *The study applies a combination of theoretical analysis, comparative assessment, and regression modeling to provide a comprehensive examination of economic growth drivers.*

Results. *In this study, using empirical analysis, it was found that the most important factors of economic growth were the amount of investment in real assets, the effectiveness of public spending, and investment in science and technology. However, the quality of institutions and demographic changes require a deeper analysis, since their impact has been ambiguous.*

Empirical analysis has shown that the significant factors of economic growth are the volume of investment in real assets, the rate of population growth, and the share of international trade in GDP. In contrast, the quality of institutions and spending on education and R&D require deeper analysis, since their impact is not observed in the short term.

Conclusions. *Based on the analysis of theoretical models and empirical findings, the key factors that have the greatest impact on the growth rate of GDP per capita have been identified. Drawing on both the theoretical analysis and empirical results, practical recommendations were formulated for Ukraine's future economic strategy. Today, the urgent need to define and build a path to post-war recovery and further economic growth in Ukraine makes this research relevant.*

Keywords: *economic growth, economic growth drivers, developing economies, gross domestic product, factors of production, panel data model, modelling.*

Background

Economic growth in developing economies remains one of the most critical issues in contemporary economic research. The increasing integration of global markets and the rapid technological advancements have significantly influenced the pace and patterns of economic development across countries. However, despite these advancements, many developing economies continue to face structural challenges that hinder their sustained growth.

Identifying the key drivers of economic growth is essential for formulating effective policies that can enhance long-term development and stability. Traditional economic growth models provide fundamental insights into the mechanisms of economic expansion. However, these models do not fully capture the complexity of contemporary economic realities, including institutional factors, technological progress, and human capital development.

The experience of countries that have successfully transitioned from developing to advanced economies in recent decades offers valuable lessons. Analyzing these cases allows us to identify patterns and factors that contribute most effectively to economic growth. Therefore, studying the drivers of economic growth in developing European economies is crucial for understanding how these countries can accelerate their progress and achieve sustained economic growth.

Literature review. The exploration of economic growth in developing countries has evolved significantly over the past decades, mainly focusing on the mechanisms that contribute to long-term development in the global context. Some publications are based on economic growth foundations, such as the Solow-Swan model and endogenous growth models, while expanding to incorporate country-specific conditions, structural constraints, and institutional realities typical for developing economies. Thus, theoretical foundations of economic growth may be found in (Solow, 1956; Kaldor, 1961; Diamond, 1965; Kuznets, 1971; Lucas, 1988; Romer, 1990; Krugman, 1994) and etc. They mainly considered technological progress as the main pillar of economic growth in the long run. For example, Romer treated technological progress as "improvements in the instructions for mixing raw materials" (Romer, 1990). In addition, he distinguished social infrastructure (fiscal policy, government actions and etc.) to be a factor of economic growth (Romer, 2011). For Young (Young, 1995), long-term growth is ensured only by raising the total factor productivity (TFP). At the same time, Kuznets considered epochal innovations ("breakthroughs" in the level of human capital) as the main trigger of economic growth (Kuznets, 1971).

Some empirical studies focus on identifying key variables that statistically correlate with gross domestic

product (GDP) growth in low- and middle-income countries. These studies, using panel data models, often converge on the view that growth is driven by a mix of domestic and external factors, including capital accumulation, labor force dynamics, technological adaptation, and the quality of governance. For instance, Beqiraj, Fedeli and Giuriato (2025) studied the impact of counterfeiting on economic growth in Italy during 2008–2019 and demonstrated its ambiguous effect on economic growth. Yeboah et al. (2024) explored the drivers of inclusive growth in the BRICS countries by applying wavelet analysis, focusing on relationships between life expectancy, environmental sustainability, and economic growth. Feliciano, Ferreira and Rodriguez-Fuentes (2025) studied the peculiarities of growth drivers depending on the three growth regimes in Spain during 2000–2019. Minh and Tran (2025) used a panel data model for Vietnam to demonstrate that FDI inflows stimulate economic growth and governance quality, decreasing the informal economy. At the same time, poverty and unemployment drive Vietnam's informal economy. The study of Yilmazkuday (2025) is devoted to the research of drivers of growth spillovers across 85 countries during 1961–2022. Due to the results of the research, "growth spillovers are statistically significant for 97% of the advanced economy pairs, whereas this ratio reduces to 56% for spillovers from advanced economies to emerging markets and developing economies". Younas, Qureshi, and Al-Faryan (2022) showed that financial inclusion provides a positive impact on economic growth; at the same time, the size of the shadow economy demonstrates a significant negative effect by using a panel data model with fixed effects for developing economies during the period 2008–2017. In addition, in (Zhylynska et al., 2020) and (Bedianashvili, & Kokhreizze, 2024), the economic growth factors are analyzed for economies on the way to the EU integration, especially concerning R&D impact, in (Bazhenova, 2023) the economic growth drivers in the post-war period are revealed.

Moreover, other contributions to the literature emphasize the heterogeneity of development paths. Scholars argue that there is no one-size-fits-all formula for growth in developing countries, challenging the universality of traditional models. For instance, cross-country analyses by Rodrik (Rodrik, 2003; 2007) and Hausmann (Hausmann et al., 2005) highlight that policy space, institutional capacity, and even historical contingencies shape growth outcomes in ways that resist simple categorization.

Another important trend in the literature is the attention given to growth sustainability. Researchers increasingly assess not only how fast countries grow, but also the quality and inclusiveness of that growth. This includes considerations such as income inequality, environmental degradation, and political stability. The "quality of growth" paradigm, as explored by Sen (Sen, 1999) relates development more closely to human well-being than mere GDP metrics, adding complexity to the search for growth drivers.

To summarize, the literature on drivers of economic growth in developing economies paints a picture of high complexity and variability. While some common drivers can be identified, such as the role of investment, trade, and education, the effectiveness of these drivers is mediated by institutional quality, political stability, and global economic conditions.

The research objective of this study is to analyze the key drivers of economic growth in developing European countries to determine the most influential drivers in their economic expansion.

That is why the following tasks have been set:

- Examine the theoretical foundations of economic growth, focusing on traditional and modern growth models.
- Identify and analyze drivers not included in traditional models but significantly impacting economic development.
- Conduct a case study analysis of countries that have recently transitioned from developing to advanced economies.
- Construct a regression model to empirically determine the most effective drivers of economic growth.
- Propose policy recommendations based on the theoretical and empirical findings.

Methods

The econometric approach used to estimate the relationship between GDP per capita growth and various explanatory variables is based on panel data modeling techniques. The model is specified as follows:

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \dots + \beta_k x_{kit} + \varepsilon_{it},$$

$x_{1it}, \dots, x_{kit}$ represent the explanatory variables (excluding the intercept), α_i denotes individual-specific intercepts that vary across observational units i , ε_{it} are random error terms, assumed to be independently and identically distributed with a mean of zero and constant variance σ_ε^2 .

Results

Economic growth is a fundamental process that reflects the ability of a national economy to increase its output of goods and services over the long term. In the macroeconomic context, it is usually measured by the growth rate of real gross domestic product (GDP) or real GDP per capita, which allows us to assess changes in the overall welfare of the population. Growth in real GDP indicates an increase in economic productivity, more efficient use of resources, and better living standards. At the same time, it is important to distinguish between extensive and intensive types of growth: the former is achieved by increasing the number of resources used, while the latter is achieved through increased efficiency of their use, innovation, and technological progress (Romer, 2012).

In developing countries, economic growth has its own specific characteristics and challenges. These economies are often characterized by an unstable institutional framework, limited access to financial resources, low levels of technological development, and dependence on commodity exports. They may also face high unemployment, uneven income distribution, and infrastructure constraints. These factors complicate the process of sustainable economic growth and require targeted reforms and strategic planning to overcome structural problems (Bazhenova, 2023).

Economic growth is driven by a variety of drivers that stimulate economic development. Among them, the key role is played by investments in human capital, in particular in education and healthcare, which increase labor productivity. Innovations and research, and development contribute to the introduction of new technologies and processes that increase production efficiency. Infrastructure development, including transportation and energy networks, provides the necessary conditions for economic activity. In addition, a favorable business environment, political stability, and effective institutions are important prerequisites for attracting investment and supporting entrepreneurship. Successful examples of countries that have achieved high growth rates demonstrate the importance of a comprehensive approach to development that includes both domestic reforms and integration into the global economy.

Although economic development models can provide a deep understanding of the causes and drivers of economic growth, they do not take into account certain factors that cause differences in the dynamics of development between countries. While most economic models emphasize the accumulation of human and physical capital as the main driver of economic growth, Easterly and Levine have devoted a separate paper to the study of drivers other than value accumulation (Easterly, & Levine, 2001). The basis of their research is the concept of Total Factor Productivity (TFP), which the authors consider as a factor that accounts for the differences in growth levels across countries. TFP is defined as the portion of output growth that cannot be explained by an increase in measurable inputs. It reflects enhancements in labor productivity driven by factors such as technological innovation, externalities, institutional adoption, legal frameworks, and property rights.

Rodrik (Rodrik, 2007) provides strategies and advice on economic growth policy in developing countries. He analyzed the economic policies and measures taken by the governments of actively developing countries at the end of the last century and compared them with economic indicators. His study identified geography, international integration, and institutions as the main determinants of economic growth beyond capital accumulation.

Following the works of the scholars mentioned above, innovation, international integration, geography, demographics, and institutions are the major factors that should be considered as key drivers of growth outside of traditional economic models (Prasetyo, 2012).

Technological innovation is a major driver of economic growth since it raises productivity, generates new industries, and creates market opportunities. Technological advancement, through simplification and automation processes, enables companies to produce more efficiently, resulting in greater aggregate output. A case in point is the application of computer-aided design (CAD) software in manufacturing, which has revolutionized product development with the capability to rapidly prototype and precision, reducing production cycles and costs (Toxigon, 2025).

Besides optimizing existing processes, technological innovation gives rise to whole new industries. The internet, for example, has spawned e-commerce websites, digital marketing companies, and the gig economy, all of which have contributed enormously to economic growth by offering new sources of income and jobs. Similarly, progress in biotechnology has transformed the health sector through the production of customized medicines and advanced diagnostic apparatus, enhancing health outcomes and reducing spending on healthcare (MilanoIP, 2025).

Publicly funded R&D investments lie at the heart of sustaining such growth based on innovation. Publicly funded R&D has high social returns, as evidenced by the past provision of productivity growth. For instance, it is argued that publicly funded R&D has significantly contributed to the U.S. productivity since World War II, highlighting that more investment in technological research is essential for ensuring economies remain competitive (Financial Times, 2025).

At the same time, the relationship between technological advancement and increased productivity is not necessarily obvious. "Productivity paradox," coined by Robert Solow, means those instances in which technological change does not become evident as increases in predicted productivity levels in numbers. While technologies such as AI have proliferated, there has been some stagnating growth in productivity. For example, Britain has seen an average productivity growth of just 0.3% per year over the past 16

years, which suggests that the reward for technological innovation may not always show in economic statistics immediately (The Times, 2025).

International integration, including the flows of trade, investment, and the exchange of ideas through which countries become participants in the global round of permanent economic expansion, is critical for economic development. For developing countries, this integration is particularly significant as it offers avenues for accelerated development and poverty reduction.

One of the primary benefits of international integration is the expansion of markets. By engaging in global trade, developing nations can access a broader customer base beyond their domestic markets, leading to increased production and economic expansion. With this access, those countries can specialize in sectors where they have a comparative advantage, so they are better off due to more efficient allocation of resources and output.

International integration also draws in foreign direct investment (FDI), an essential driver in infrastructure building, technology transfer, and promotion of employment. FDI brings in capital that can be utilized for building essential infrastructure such as roads, ports, and telecommunications, thereby improving the overall business environment. Foreign investments may also entail new technologies and managerial approaches that improve worker productivity and thus the competitive capacity of local industries. According to the World Bank, the promotion of regional integration assists countries in breaking natural barriers to the trade of goods, services, capital, labor, and knowledge that are growth inhibitors, especially for developing countries (International Monetary Fund (IMF), 2001).

Engagement in global value chains (GVCs) is also a channel by which internationalization drives growth at the macro level. By integrating into GVCs, developing countries can access the international market at certain stages of production processes, allowing them to participate in international markets without having to develop entire industries domestically. This engagement may result in enhanced industrialization, export diversification, and job skill development. The Trade and International Integration Research Program of the World Bank seeks to strengthen the knowledge base on the development effects of global economic integration on poverty reduction for developing countries.

However, the path to successful integration is not without challenges. Developing countries must navigate potential risks such as increased competition for domestic industries, exposure to global economic fluctuations, and the need to implement appropriate regulatory frameworks to manage integration effectively. To mitigate these risks, developing nations can engage in cooperative efforts and share technical expertise and knowledge with countries facing similar challenges. Access to technology and capacity building are crucial for equitable participation in global cooperation.

A country's favorable geographical location gives it a comparative advantage over other countries, allowing it to use its significant mineral reserves and proximity to international trade routes to accelerate its economic growth. This is especially relevant for developing countries, as it allows them to compensate for their economic weaknesses and integrate into the global system. Elements such as location, climate, and terrain significantly affect income levels and growth rates, affecting transportation costs, the spread of disease, and agricultural productivity. For example, landlocked countries typically face higher transportation costs and limited access to international markets, which can hinder trade and economic growth.

Another important driver that is part of the geographical location is the availability of natural resources and minerals. Such a privilege significantly increases the country's economic potential in the global market and makes it more independent from others in terms of resource availability.

Norway is a perfect example of how to use natural resources for economic benefit in a country. North Sea oil and gas, the largest reserves of hydrocarbons in the world, have become the impetus for the development of an energy sector that accounts for around half of the country's exports and 17% of its GDP. Moreover, Norway uses almost 100% renewables (mainly hydro) for consumption (Enerdata, 2025), making it feasible for the country to export most of its fossil resources and ensuring a high standard of living.

Demographic indicators and tendencies play an important role in determining economic growth trajectories, especially in developing countries. Recent research by the IMF, World Demographics and Aging Forum, and other international think tanks uncovers the growing interrelation between population age structure and economic metrics while highlighting challenges as well as opportunities (IMF, 2020).

The notion of "demographic dividend" means the growth potential that becomes possible due to changes in the age structure of the population, namely, when the share of the workforce in a country rises compared to the disabled groups. The research that estimated South Asian Association for Regional Cooperation (SAARC) countries showed the existence of a positive correlation between the demographic dividend and economic expansion of countries in the period from 1990 to 2017. The research underscored that to use this opportunity fully, these nations need to have policies in place that nudge their labor forces toward full employment, since an underutilized skill set can decrease the potential gains (Nusrat et al., 2021).

On the other side, as other research proves, an increasing number of elderly individuals may become a nudge for positive economic trends. The research covered 84 developing countries in the period between 1971 and 2015. The conclusion was the following: a higher share of young dependents (children under 14 years old) negatively affects economic growth in the long run, while a higher number of older individuals (65 and older) can have a positive influence, meaning that older people can be more efficient in specific fields. However, relationships between these indicators are very complex and heavily depend on the specifics and context of each researched economy (Pham, & Vo, 2019).

Also, international trends point to an up-and-coming "youth scarcity" crisis by way of rapidly declining fertility rates with major economic implications as populations age. The trend of this severity questions traditional economic systems that require a large supply of working younger people to support retirees, leading to fears over the sustainability of the pension system and higher intergenerational economic costs.

Another crucial driver that shapes economic growth is the quality of a country's institutions. Institutions are usually described as legal, political, and social frameworks that set the behavior of individuals and organizations in the economy. Their quality determines the efficiency of the economic system. Strong institutions ensure the fair functioning of the markets, protection of property rights, and accessibility of all benefits from people's work and innovations. In the institutional approach of economic theory, strong institutions are valued as important conditions for economic growth.

Recent empirical researches support the theoretical facts. Yildirim and Gökalp (2016) analyzed 38 developing

countries in the period between 2000 and 2011 and demonstrated that the quality of institutions strongly correlates with macroeconomic indicators. Their panel data analysis found key institutional variables that dramatically increase the GDP per capita: integrity of the legal system, trade openness, and labor market flexibility. For example, an improvement in legislation was found to raise income per capita by 8,6%. It illustrates the critical role of trustworthiness in facilitating economic transactions.

At the same time, drivers such as ineffective legislative systems, excessive government spending, and unstable political environments impair economic growth. The research also revealed an unexpected finding: Greater judicial independence without parallel reforms, which in combination can increase efficiency, does not always lead to higher economic output.

Over the past three decades, against the backdrop of increasing globalization and political and economic integration of European countries, the process of economic growth has become increasingly differentiated, and the mechanisms of drivers influencing the pace of development have become increasingly complex. Eastern European countries are particularly interesting for this study, as most of them, sharing a common soviet past, have gone through a process of changing economic, social, and political ideologies and principles, and have radically altered the structure of their internal markets and economic growth models. Despite similar starting conditions after the collapse of the soviet union, the countries of the region have demonstrated very different dynamics of economic development. Some of them have managed to take advantage of the historical moment and build an effective growth model, while others remain in the group of countries with economies in transition, facing lingering barriers to sustainable development.

Among the key drivers of economic growth in European developing countries are institutional reforms, integration into the European Union, attraction of foreign direct investment, development of innovations, and infrastructure. However, not all countries in the region were able to equally take advantage of these opportunities. For example, Hungary experienced an economic decline of 0.2% in the first quarter of 2025 compared to the previous quarter, which was the fourth fall in six quarters. This is due to low business confidence, reduced investment, and weak external demand. On the other hand, the Czech Republic showed stability, growing by 0.5% in quarterly terms and 2.0% in annual terms, mainly due to consumer demand (Reuters, 2025a).

In the Western Balkans, such as Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia, the World Bank predicts collective economic growth of 3.2% in 2025. This growth is supported by lower inflation, rising wages, increased public investment, and robust consumer demand. However, the region faces challenges such as political instability, slow economic activity in the EU, and global trade fluctuations (Reuters, 2025b).

One of the most striking examples of a successful transition is Estonia. Despite the lack of significant natural resources and a small domestic market, the country was able to make an "economic leap" thanks to clear political will, transparent institutional reforms, early digitalization, investment in human capital, and rapid integration into the European Union. These factors have become the drivers that have made Estonia one of the few post-Soviet states that has been able to reach the level of development similar to Western European countries in some respects.

In contrast, Ukraine, a country with much greater potential – strategic geographic location, richer resources, large domestic market, and a highly educated population – still faces difficulties in implementing a sustainable growth strategy. Economic growth is significantly constrained by such factors as chronic political instability, corruption, a weak legal system, low trust in institutions, and delays in the implementation of key economic reforms. In addition, external factors such as the annexation of Crimea and, since 2022, full-scale military aggression by Russia have had a significant negative impact.

Historically, Estonia gained independence after the collapse of the USSR in 1991. At that time, the country faced

typical post-socialist problems, such as outdated infrastructure, inefficient state-owned enterprises, a closed market, and hyperinflation. Nevertheless, the Estonian government concluded in favor of applying a shock therapy strategy. This economic practice involves rapid and fundamental changes through radical political reforms. Deep macroeconomic and structural changes were implemented, a national currency (kroon) was created, and the legal system was built on the German model. This liberal approach laid the foundation for the country's rapid modernization. At the time of the collapse of the USSR, Estonia's GDP per capita was on par with the other Baltic countries, but as of 2024, it is significantly ahead of them (Fig. 1).

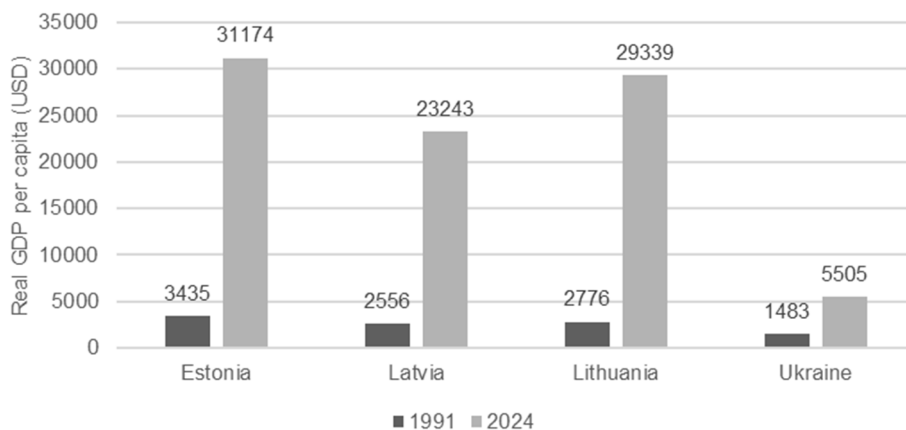


Fig. 1. Real GDP per capita in Baltic countries and Ukraine in 1991 and 2024

Source: compiled by authors based on (Countryeconomy, 2025)

Since gaining independence in 1991, Ukraine has begun the transition from a planned to a market economy. However, unlike Estonia, the reform process has been less consistent, resulting in delays in the development of institutions and economic structure. In the period from 2000 to 2008, Ukraine experienced a period of economic growth, in particular due to favorable external economic conditions, export growth, especially in metallurgy and machine building, and rising domestic consumer demand. GDP grew by an average of 7% annually. However, the global financial crisis of 2008 hit the Ukrainian economy hard. In 2009, GDP declined by 14.8%, driven by lower external demand, falling prices for export goods, hryvnia devaluation, and a crisis in the banking sector. Nevertheless, the economy began to recover in 2010, with GDP growth of 4.1%, driven by favorable external conditions and rising domestic demand. Since 2014, the country has faced military aggression from Russia, which has significantly complicated the economic situation. The full-scale invasion in 2022 caused a 29.1% drop in GDP due to the destruction of infrastructure, the blockade of ports, and mass migration.

Despite these challenges, the Ukrainian economy is showing signs of recovery. In 2023, real GDP grew by 5.3%, exceeding the expectations of most analysts. This growth was driven by businesses adapting to the war conditions, increased investment activity, and support from international partners. In particular, investment activity grew by 52.9%, indicating renewed confidence in the economy. In 2024, GDP is projected to grow by 4%, although the growth rate may slow to 2.7% in 2025 due to ongoing security risks, energy challenges, and labor shortages (Ukraine Business News, 2024).

Thus, to analyze the impact of various drivers on economic growth, the panel regression model with fixed effects has been used.

Given the production function of the form $Y = A f(K, L, H)$, where Y is output, A is total factor productivity, K is capital stock, L is labour, and H is human capital, for the purpose of exploring the effect of economic growth factors, we used such indicators.

First of all, economic growth will be measured in annual real GDP growth (in percent). To measure the Capital stock, the indicator of gross capital formation as a percentage of real GDP was applied. The Labour will be presented in the form of an annual increase in the labor force. Human Capital will be measured as the level of quality of education. To study this factor precisely from the point of view of the government policy, it was decided to measure this indicator as public spending on education for the year (as a percentage of real GDP).

Moreover, based on the theoretical analysis outlined above, we included the following drivers:

- The level of participation in international trade is measured as a percentage of international trade in the real GDP.
- The level of innovation development is reflected in expenditure on Research and Development (% of real GDP).
- Institutions' efficiency will be represented by the Government Effectiveness index that measures the quality of public institutions' services, and their independence from political pressures.

In the research, we explored 20 European economies – emerging and developing Europe – in accordance with the classification of the International Monetary Fund, as well as countries that joined the EU after 2004. They are Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovak Republic, Slovenia, Turkey, and Ukraine (Kosovo is excluded due to a lack of data). The data covers the period

from 2001 to 2023. The source of data is the World Bank Open Data database.

Therefore, the econometric model has the following form:

$$GDPgrowth_{it} = \beta_0 + \beta_1 Lgrowth_{it-1} + \beta_2 I_{it} + \beta_3 EDUC_{it-5} + \beta_4 TRADE_{it} + \beta_5 R\&D_{it-5} + \beta_6 GEI_{it} + \varepsilon_{it},$$

$$i = 1, \dots, 20; t = 1, \dots, 23,$$

where $GDPgrowth_{it}$ – annual Real GDP per capita growth rate (%); $Lgrowth_{it-1}$ – annual labor force growth rate (%) with lag 1; I_{it} – investment in real assets as % of Real GDP; $EDUC_{it-5}$ – public spending on education as % of Real GDP with lag 5; $TRADE_{it}$ – share of International trade as % of Real GDP; $R\&D_{it-5}$ – share of spending on the R&D as % of Real GDP with lag 5; GEI_{it} – government effectiveness index; ε_{it} – perturbations.

Table 1 gives the estimates of regression parameters for a sample of twenty European countries for 2001–2023 for the model mentioned above. We observe that three out of six explanatory variables are statistically significant. Given that economic development is influenced by a wide array of institutional, structural, political, and external factors – many of which are difficult to fully quantify or capture in a single econometric model – it is common for panel data regressions to yield modest R^2 values.

Table 1

Results of panel data model estimation

Dependent variable	Per capita GDP growth rate
Independent variables	Coefficients
Intercept	-19.19 (-3.59) ¹
Lgrowth(-1)	-63.80** (-3.31)
I	0.40*** (4.34)
EDUC(-5)	0.32 (0.67)
TRADE	0.08*** (3.94)
R&D(-5)	0.65 (0.46)
GEI	0.43 (0.22)
R-squared	0.439
Adjusted R-squared	0.426

Note: *** – significance at 1%, ** – significance at 5%; ¹ – t-statistics are in brackets.

Among the independent variables, the strongest positive effect is demonstrated by Capital investment. This result suggests that an increase in investment in real assets strongly stimulates economic growth. Thus, investments appear to be a key driver of development for the selected group of countries. On the contrary, we may conclude that public spending on education is used inefficiently or that its effects appear only in the long run and are not reflected in short-term growth. The positive impact of the share of International trade proves foreign trade to be an inevitable driver of sustained economic growth.

In developing European countries, there can be a negative relationship between GDP per capita growth and population growth due to several economic and demographic dynamics. First of all, population growth may be a consequence of migration processes in Europe. It puts pressure on infrastructure, education, healthcare, housing, and public services. Governments in developing countries often struggle to keep up with these demands, leading to lower productivity per worker, poorer education and health outcomes, and slower improvements in living standards.

Moreover, more people entering the labor force without matching job creation can cause high unemployment or underemployment, and lower wages due to excess labor supply. This reduces household income and limits consumption and investment, slowing GDP per capita growth. In addition, with rapid population growth, governments may struggle to maintain education and healthcare quality. This limits the development of human capital, reducing productivity and long-term economic growth per capita. Thus, moderate or slower population growth often aligns more closely with sustained per capita income growth in these contexts.

In developing European countries, R&D and education expenditures may not influence GDP per capita significantly due to long time lags, structural inefficiencies, talent migration, weak linkages between research, industry, and policy, and, finally, broader economic and institutional challenges.

In conclusion, using empirical analysis, it was found that the significant drivers affecting economic growth are investment in real assets and the share of International trade. At the same time, the quality of institutions and demographic changes require a deeper analysis, since their impact has been ambiguous. This emphasizes that it is critically important for developing countries not only to invest, but also to improve resource utilization mechanisms and efficiency of the institutional framework.

Discussion and conclusions

Discussion. Based on the theoretical background of economic growth and the results of empirical research, we have identified the key drivers of GDP growth in developing European countries. In this context, we might highlight the main pillars of economic strategy in Ukraine. Thus, the formation of an effective political and economic strategy of Ukraine should be based on stimulating investment activity, increasing the efficiency of public spending, especially in the field of education and innovations, improving the institutional environment, and integration into global economic processes.

First of all, it is extremely important to create a favorable environment for attracting both domestic and foreign investments. Moreover, special attention should be paid to reforming the judicial system, ensuring the protection of property rights, combating corruption, and simplifying regulatory procedures. Liberalizing access to financing, developing the capital market, and introducing effective mechanisms to support the private sector are key prerequisites for expanding investment in the economy. In April 2025, Ukraine and the US signed an agreement to establish a Joint Reconstruction Investment Fund to finance projects in the critical materials, oil, gas sectors and etc. The fund will leverage foreign investment and technology support, particularly through the U.S. International Finance Corporation, and all profits are expected to be reinvested in Ukrainian infrastructure tax-free for the first ten years. Additionally, it is advisable to introduce mechanisms for political insurance of investments and expand institutional support for small and medium-sized businesses. Transparent tax incentives, simplification of registration and licensing procedures, as well as the creation of mechanisms for assessing the effectiveness of investment projects, can significantly increase the investment attractiveness of Ukraine.

Public spending should be refocused on projects that have a high return in the long run. In particular, it is important to ensure not just an increase in education spending, but also an increase in their efficiency through the modernization of educational programs, the development of STEM areas, and support for vocational and higher education focused on the needs of the labor market. Ukraine is implementing a Strategic Action Plan until 2027, which

envisages the digital transformation of education, the development of qualification frameworks, and partnerships between the public and private sectors. Also, the "New Ukrainian School" reform is aimed at the personal development of students and the acquisition of key competencies that meet the requirements of the contemporary labor market. At the same time, it is necessary to create conditions for the effective commercialization of scientific developments, in particular by stimulating private-public partnerships in the field of R&D. Further, it is important to integrate higher education institutions with enterprises through the development of dual education programs, support for IT education, and stimulation of research activity at universities.

Special attention should be paid to the development of the innovation ecosystem. Spending on research and development should increase not only in absolute terms but also be accompanied by reforming the science management system, stimulating venture capital, developing the startup industry, and attracting international technological partnerships. In this case, investment in innovation will be transformed into a real increase in productivity. The Association Agreement between Ukraine and the EU, including the Deep and Comprehensive Free Trade Area, has granted Ukraine preferential access to the EU single market, contributing to economic diversification, export growth, and job creation.

From the point of view of international integration, Ukraine should continue to expand access to world markets, reduce barriers to trade, and more actively integrate into regional economic associations. Deepening cooperation with the European Union, the implementation of its standards in the regulatory and technical spheres will contribute not only to increasing the competitiveness of domestic products but also to ensuring a high-quality institutional environment. In addition, Ukraine should intensify trade diplomacy, stimulate the expansion of enterprises into the markets of Asia, the Middle East, and Africa, and develop logistics infrastructure and export support tools. The introduction of digital platforms to support exporters, export credit and guarantee systems, as well as improving the institutional architecture of foreign trade support, will increase the international competitiveness of Ukrainian enterprises.

Taking into account demographic challenges, especially the decrease in the share of the working-age population due to emigration and aging, it is necessary to develop a comprehensive policy to support the birth rate, attract labor migrants, and the reintegration of citizens who have left abroad. The demographic situation in Ukraine is difficult, in particular due to military aggression, a decrease in the birth rate, an aging population, and mass migration that has an impact on human social security (Bazhenova, Banna, 2025). According to UNFPA, the Government of Ukraine, with the support of international partners, is implementing the National Demographic Strategy aimed at improving conditions for young people and families, developing health care and education. In addition, the active implementation of programs for improving the skills and retraining of the population will help maintain high labor productivity. Separately, it is worth noting the importance of introducing a policy of "positive migration" - creating conditions for the return of Ukrainians from abroad, supporting the integration of foreign specialists, as well as developing mechanisms to stimulate labor mobility within the country. In the long run, it is appropriate to formulate a policy of balanced regional development in order to reduce urbanization pressure on

large cities and support the sustainable development of small communities.

To sum up, we would like to stress that the implementation of such a comprehensive policy will not only ensure sustained economic growth, but also create the prerequisites for a long-run increase in people's well-being and Ukraine's convergence towards the advanced economies.

Conclusions. This research aimed to analyze the drivers of economic growth in developing European countries, with a particular focus on recommendations for Ukraine's economic recovery strategy.

Aside from looking at well-known drivers from traditional economic growth theories, such as capital and labor force growth, we focused on such drivers of development as technological innovation, international economic integration, geographical conditions, demographic trends, and institutional quality. Each of these aspects was shown to have a meaningful influence on the pace and sustainability of economic growth, particularly for developing European economies. As an example, we conducted a comparative analysis of Estonia and Ukraine cases of economic growth. Estonia's economic success was attributed to comprehensive reforms, effective governance, active digitalization, and strategic European integration. In contrast, Ukraine's economic growth was significantly constrained by institutional weaknesses, inconsistent reforms, demographic challenges, and, more recently, the devastating impact of military conflict.

Moreover, the results of the panel regression model to determine the significant drivers affecting GDP per capita growth in 20 developing European countries confirmed the strong positive impact of capital investment, highlighted the mixed effects of government expenditure on education and R&D, and revealed the complex relationship between institutional quality and economic growth.

Finally, we have formulated the pillars for Ukraine's economic recovery strategy. These include enhancing investment attractiveness, improving the efficiency of public spending, promoting innovation and human capital development, strengthening institutional frameworks, deepening international trade integration, and addressing demographic imbalances.

Commenting on the possible directions of future research, we would focus on Ukraine's convergence towards advanced economies studies.

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ДРАЙВЕРИ ЕКОНОМІЧНОГО ЗРОСТАННЯ: ЕМПІРИЧНІ ВИСНОВКИ ДЛЯ КРАЇН ЄВРОПИ, ЩО РОЗВИВАЮТЬСЯ

Вступ. Актуальність статті зумовлена постійною важливістю економічного зростання в країнах, що розвиваються, як одного із центральних об'єктів сучасних економічних досліджень. Зростання інтеграції глобальних ринків і стрімкі технологічні зміни суттєво вплинули на темпи та структуру розвитку країн. Визначення фундаментальних чинників цього зростання є ключовим для формування політик, що забезпечують довшострокову стабільність і сталий розвиток. Досвід країн, яким вдалося успішно перейти від статусу таких, що розвиваються, до розвинених, надає цінні емпіричні докази. Аналіз цих випадків дозволяє виявити найважливіші фактори, що сприяють економічному зростанню. У цьому контексті вивчення чинників зростання в країнах, що розвиваються, в Європі, набуває особливої важливості для розуміння їхніх перспектив прискореного та сталого розвитку.

Методи. У дослідженні застосовано поєднання теоретичного аналізу, порівняльного оцінювання та регресійного моделювання з метою комплексного вивчення чинників економічного зростання.

Результати. У результаті емпіричного аналізу встановлено, що найважливішими факторами економічного зростання є обсяг інвестицій у реальні активи, темп зростання населення та питома вага міжнародної торгівлі у ВВП. Водночас якість інститутів і видатки на освіту й R&D потребують глибшого аналізу, оскільки їхній вплив виявився неоднозначним.

Висновки. На основі аналізу теоретичних моделей, чинників економічного зростання і результатів емпіричного дослідження визначено ключові фактори, які мають найбільший вплив на темпи зростання ВВП на одну особу. З огляду на теоретичні підходи й емпіричні результати, сформульовано практичні рекомендації для майбутньої економічної стратегії України. Нині нагальна потреба у визначенні та побудові шляху післявоєнного відновлення й подальшого економічного зростання робить це дослідження особливо актуальним.

Ключові слова: економічне зростання, чинники економічного зростання, країни, що розвиваються, валовий внутрішній продукт, фактори виробництва, панельна модель, моделювання.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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FUZZY COGNITIVE MAPS FOR HIGH-TECH COMPANIES' RESILIENCE MODELING

Background. *Relevance.* Modern high-tech companies are dealing with more uncertainty and a range of complex threats, such as cyberattacks, infrastructure disruptions, and personnel challenges. Building resilience in these businesses is now essential for the national economy. *Objective.* This study aims to develop a cognitive model for assessing the resilience of high-tech companies under complex threats based on fuzzy cognitive maps.

Methods. The fuzzy cognitive map (FCM) method combined with fuzzy DEMATEL was used to determine factor weight coefficients. An expert survey of 10 top managers was conducted to assess the relationships between factors. The agreement among experts was assessed using Kendall's coefficient of concordance ($W = 0.864$, $p < 0.01$). Impulse modeling was applied to analyze system dynamics.

Results. The resulting FCM, with weights determined through Fuzzy DEMATEL, identified cyber threats as the most critical negative factor (-0.32) and physical infrastructure as the most significant positive factor ($+0.28$) influencing overall company resilience.

Conclusions. The proposed model shows how different factors influence a company's resilience and helps managers set clear priorities. In practice, it can be used to model crisis scenarios and guide better resource allocation to strengthen business resilience.

Keywords: fuzzy cognitive map; fuzzy DEMATEL; enterprise resilience; impulse modeling.

Background

The events of the past decade, including the COVID-19 pandemic and various military conflicts, have highlighted the vital role of organizational resilience as the ability to adapt to extreme conditions while maintaining functionality and competitiveness (Dahmen, 2023). This issue is particularly acute for Ukrainian businesses, which have operated under constant security challenges since 2014 and, since 2022, under martial law (Opatska, Gajić, & Kaščelan, 2024).

In general, the modern business environment is characterized by unprecedented turbulence and uncertainty. High-tech companies, including those in the IT industry, start-ups, and Research and Development (R&D) firms, face complex threats that simultaneously affect different aspects of their operations: cybersecurity, physical infrastructure, human resources, and financial stability (Duchek, 2020; Kaporcic et al., 2025).

These complex threats rarely happen on their own. They often interact and make each other worse, which traditional risk assessment methods have trouble capturing. For example, a cyberattack can harm information systems and also disrupt operations, lower staff morale, shake customer trust, and hurt financial stability. Infrastructure failures can reveal security gaps and use up funds needed for recovery. Because these risks are so connected, we need assessment tools that show how they influence each other, not just treat them as separate problems. This necessitates cognitive approaches that account for nonlinear links, feedback loops, and cascading effects in the "enterprise-environment" system (Papageorgiou et al., 2020).

The purpose of this study is to develop and validate an integrated fuzzy cognitive map model for assessing organizational resilience of high-tech companies operating under complex threat environments, and to identify critical resilience factors to inform strategic management decisions.

Literature review. Fuzzy cognitive maps (FCMs) were proposed by Bart Kosko in 1986 as an extension of Axelrod's cognitive maps using fuzzy logic (Kosko, 1986). FCMs are

directed graphs that model causal relations between system concepts, with weights in the range $[-1, 1]$, where the sign indicates direction (positive/negative) and the magnitude indicates strength (Kosko, 1992).

Applications of FCMs in economics and management have expanded since the 2000s. Xirogiannis, Glykas and Staikouras (2010) demonstrated the use of hierarchical FCMs for strategic planning in banking. Glykas, Xirogiannis, and Staikouras (2012) extended this to dynamic Key Performance Indicators modeling. Recent work emphasizes hybrid approaches. Poczeta, Papageorgiou and Gerogiannis (2020) proposed nested FCMs with genetic algorithms, while Papageorgiou et al. (2020) developed an aggregation method using ordered weighted averaging operators for sustainable development planning. Kokkinos et al. (2018) applied FCMs to assess the socio-economic impacts of industrial projects. In Ukraine, cognitive modeling in economics has been developed by scholars at Taras Shevchenko National University of Kyiv (e.g., Bazhenova, & Bazhenova, 2016).

Decision Making Trial and Evaluation Laboratory (DEMATEL) was created in the 1970s to analyze complex causal systems. Wu and Lee (2007) introduced fuzzy DEMATEL for managerial competencies, highlighting the advantages of fuzzy expert processing. Chang, Chang and Wu (2011) integrated fuzzy DEMATEL with the Analytical Network Process for supplier selection. Li et al. (2011) adapted it to identify critical success factors in emergency management. Zhou, Huang and Zhang (2023) used fuzzy DEMATEL with Triangular Fuzzy Numbers (TFN) for urban safety.

Organizational resilience has advanced substantially over the last decade. Duchek (2020) conceptualizes resilience as a meta-capability that encompasses anticipation, coping, and adaptation. Zhang, Dou and Wang (2025) empirically link resilience and sustainability for Chinese firms. Dahmen (2023) posits resilience as a core property of enterprise risk management in the face of black swans. Settembre-Blundo et al. (2021) propose a

multidimensional risk system that integrates sustainability. Opatska, Gajić and Kaščelan (2024) provide wartime crisis-management insights from Ukraine.

Building on these methodological foundations, the following section describes our integrated approach combining FCM construction, fuzzy DEMATEL weighting, and impulse simulation.

Methods

Fuzzy Cognitive Map Construction. An FCM is formally described as a pair $\langle K, W \rangle$, where $K = \{K_1, K_2, \dots, K_n\}$ is a set of concepts (factors), $W = ||w_{ij}||$ is a matrix of connection weights between them. The weight $w_{ij} \in [-1; 1]$ characterizes the strength and direction of influence of concept K_j on concept K_i :

- $w_{ij} > 0$ – positive influence (increase in K_j causes growth in K_i);
- $w_{ij} < 0$ – negative influence (increase in K_j leads to decrease in K_i);
- $w_{ij} = 0$ – absence of direct connection.

Model Factor Determination. Factor selection is based on the following research:

1. Theoretical analysis – literature review (Duchek, 2020; Koporcic et al., 2025; Opatska, Gajić, & Kaščelan, 2024) on organizational resilience revealed the 5 most frequently mentioned factors;
2. Preliminary pilot study – interviews with 10 top managers of Ukrainian high-tech companies confirmed the relevance of these factors.

Based on literature analysis and preliminary expert interviews, 5 key factors were identified:

1. Cyber threats (K_1) – integral indicator of cybernetic and information threats.
2. Physical infrastructure (K_2) – state of material and technical base, energy supply.
3. Financial resources (K_3) – financial stability, liquidity, access to capital.
4. Human capital (K_4) – availability of qualified personnel, team competencies.
5. Managerial flexibility (K_5) – management adaptability, decision-making speed.

The resulting concept – Company Resilience (R) – is an integral resilience indicator.

Fuzzy DEMATEL Method. To construct a meaningful FCM, it is necessary to determine the weight of the causal links between factors. While these can be estimated directly by experts, such an approach may fail to capture the deeper structure of the system. To address this, this study employs the Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. This research method serves two main purposes. First, it provides a structured process for aggregating the subjective judgments of multiple experts. By using fuzzy logic, and specifically Triangular Fuzzy Numbers (TFNs), the model can handle the uncertainty and vagueness in human linguistic assessments, offering a more robust analysis than methods relying on crisp numerical inputs. Second, DEMATEL measures how much each factor affects the system and how much it is affected by others. By comparing these results, it sorts factors into two important groups: 'cause' factors, which drive changes in the system, and 'effect' factors, which are shaped by other variables. (Li et al., 2011; Chang, Chang, & Wu, 2011):

Stage 1. Expert evaluation in linguistic form with conversion to triangular fuzzy numbers (TFN) (Table 1).

TFN Parameters Explanation. Each linguistic term is converted to a triangular fuzzy number (TFN) represented as (l, m, u) , where:

- l (left) – the lower bound representing the minimum possible value;
 - m (middle) – the most likely value or peak of the membership function;
 - u (upper) – the upper bound representing the maximum possible value.
- For example, "Strong influence" = $(0.5, 0.75, 1.0)$ means:
- The influence is at least 0.5 (minimum certainty);
 - Most likely 0.75 (highest confidence);
 - At most 1.0 (maximum possibility).

Table 1

Linguistic term values	
Linguistic term	TFN (l, m, u)
No influence	(0.0; 0.0; 0.25)
Weak influence	(0.0; 0.25; 0.5)
Medium influence	(0.25; 0.5; 0.75)
Strong influence	(0.5; 0.75; 1.0)
Very strong influence	(0.75; 1.0; 1.0)

Source: adapted from Li et al. (2011) and Zhou, Huang and Zhang (2023).

This triangular representation captures both the expert's assessment and the inherent uncertainty in their judgment, allowing for more subtle modeling than crisp values.

Stage 2. Aggregation of expert assessments:

$$\tilde{x}_{ij} = (1/k) \oplus (\tilde{x}_{ij}^1 \oplus \tilde{x}_{ij}^2 \oplus \dots \oplus \tilde{x}_{ij}^k)$$

Stage 3. Defuzzification using the center of gravity method:

$$x_{ij} = (l + m + u) / 3$$

Stage 4. Normalization of the direct influence matrix:

$$N = X / \max(\sum_j |x_{ij}|)$$

Stage 5. Calculation of total influence matrix:

$$T = N(I - N)^{-1}$$

Stage 6. Determination of centrality indicators:

- $D_i = \sum_j t_{ij}$ (sum of outgoing influences)
- $R_i = \sum_j i_{ij}$ (sum of incoming influences)
- $(D - R) > 0$ - cause factor
- $(D - R) < 0$ - effect factor

Impulse Modeling. While the FCM connection matrix provides a static map of the system's structure, the true value of the model lies in its ability to simulate dynamic behavior. Impulse modeling is the primary technique for conducting such dynamic analysis with FCMs. It allows researchers and managers to perform "what-if" scenario planning by simulating how a change to one or more factors propagates throughout the entire system over time. So the impulse method was used to analyze system dynamics (Kosko, 1993):

$$K_i(t+1) = f(\sum_j w_{ij} \cdot K_j(t) + \Delta K_i)$$

where f is the activation function (sigmoid), ΔK_i is the impulse in concept i .

Transitive closure matrix:

$$M = E + W + W^2 + \dots + W^m$$

where m is the number of iterations until stabilization.

Threshold Reduction. To improve interpretability, θ -reduction was applied: connections with $|t_{ij}| < \theta$ are removed. The threshold value $\theta = 0.10$ was used for the study.

Expert Survey Procedure. Ten experts were carefully selected based on specific criteria, ensuring relevant expertise: minimum 5 years of senior management experience in Ukrainian high-tech companies (IT services, software development, or R&D firms); direct responsibility for crisis management or business continuity during the 2014–2024 period; and company headcount exceeding 50 employees to ensure organizational complexity. The final

expert panel comprised 2 CEOs, 1 Chief Operating Officer, 1 Chief Information Security Officer, 2 Chief Technology Officers, 3 Senior Delivery Managers, and 1 crisis management consultant.

The assessment utilized a structured questionnaire with two components. Part A requested pairwise comparison of all five factors' mutual influences using the linguistic scale shown in Table 1 (No influence, Weak influence, Medium influence, Strong influence, Very strong influence). Experts evaluated 25 factor pairs (5x5 matrix), assessing "How strongly does factor X influence factor Y?" for each pair. Part B requested a ranking of the five factors by their overall importance for organizational resilience.

Data collection followed a modified three-round Delphi protocol to achieve consensus. Round №1 involved individual expert assessments. Round №2 presented aggregated Round №1 results to experts with outliers highlighted, allowing reassessment. Round №3 achieved consensus with a coefficient of concordance $W = 0.864$ ($p < 0.01$), exceeding the 0.70 threshold for acceptable agreement.

Expert Assessment Consistency Verification. The consistency of assessments from 10 experts was verified using Kendall's coefficient of concordance. Experts ranked 5 factors by their impact strength on company resilience.

Calculation of concordance coefficient:

$$W = \frac{12S}{m^2(n^3 - n)},$$

where $m = 10$ (number of experts); $n = 5$ (number of factors); $S = 864$ (sum of squared deviations of ranks from the mean)

$$W = \frac{12 \cdot 864}{10^2(5^3 - 5)} = 0.864.$$

The high level of concordance (86.4%) confirms the reliability of expert assessments and consensus regarding the dominant role of cyber threats (K_1) as the most critical factor affecting high-tech company resilience.

Results

The analysis of expert assessments using the Fuzzy DEMATEL method produced a weighted fuzzy cognitive map of the high-tech company resilience system. The final normalized weight coefficients, which quantify the direct influence of each of the five key factors on the integral concept of "Company resilience" (R), are presented in Table 2. Most notably, Cyber threats (K_1) emerged as the most critical factor, exerting a strong negative influence with a weight of -0.32 . This indicates that an increase in the level of cyber threats directly and significantly degrades a company's overall resilience.

On the other hand, Physical infrastructure (K_2) and Financial resources (K_3) were the top positive contributors, with influence weights of $+0.28$ and $+0.24$. This shows that having strong physical assets and stable finances is essential for a company to handle disruptions. Human capital (K_4) and Managerial flexibility (K_5) also have positive effects, but their influence is smaller, at $+0.20$ and $+0.16$.

Weight Coefficient Matrix. After processing expert assessments using fuzzy DEMATEL, a normalized influence matrix was obtained (Table 2):

Table 2

Normalized weight coefficients of factor influence on resilience			
Factor	Weight coefficient	Impact type	Rank
Cyber threats (K_1)	-0.32	negative	1
Physical infrastructure (K_2)	$+0.28$	positive	2
Financial resources (K_3)	$+0.24$	positive	3
Human capital (K_4)	$+0.20$	positive	4
Managerial flexibility (K_5)	$+0.16$	positive	5

Note: $\sum |w_i| = 1.20$ after normalization. The largest factor contribution is 0.32 , and all factors together give 1.20 units of influence.

Source: authors' calculations based on expert survey data ($n=10$ experts).

Factor Classification. To better understand how different factors influence each other in this system, we used the total influence matrix from the DEMATEL analysis to calculate centrality indicators for each factor, as shown in Table 3. This approach helps us sort the factors into net 'causes' (drivers) or net 'effects' (outcomes). The findings show a clear pattern. Cyber threats (K_1) stands out as the main driving factor, with the highest positive ($D - R$) value of $+1.60$. Physical infrastructure (K_2) and Financial resources (K_3) also act as cause factors, with ($D - R$) values of $+0.34$ and $+0.33$. These results suggest that both external threats and internal resources are the key drivers shaping the company's resilience.

Table 3

Factor centrality indicators					
Factor	D	R	D - R	D + R	Type
K_1	2.45	0.85	$+1.60$	3.30	Cause
K_2	2.12	1.78	$+0.34$	3.90	Cause
K_3	1.98	1.65	$+0.33$	3.63	Cause
K_4	1.23	2.34	-1.11	3.57	Effect
K_5	1.15	2.31	-1.16	3.46	Effect

Source: authors' calculations using the total influence matrix.

In contrast, Human capital (K_4) and Managerial flexibility (K_5) were identified as strong effect factors, with negative ($D - R$) values of -1.11 and -1.16 , respectively. This

suggests that while these capabilities support resilience, they mostly result from the company's resources and the challenges it faces.

Impulse Modeling Results. To better understand the dynamic behavior of this structured system, a series of impulse modeling experiments was conducted to simulate the impact of various shocks and interventions on overall resilience. A series of experiments with impulses $\Delta K_i = \pm 0.2$ was conducted for each factor, and the results are summarized in Table 4. The simulations show that Cyber threats have the strongest impact. Scenario S1 shows that an isolated 20% increase in the intensity of cyber threats leads to a significant 15.6% decline in overall resilience. In contrast, Scenario S4 shows that reducing these threats increases resilience by 14.8%. Strengthening infrastructure (S_2) and Finances (S_3) also helps, raising resilience by 14.2% and 11.8%.

Scenario S5 was created to explore whether combining several management actions could have a stronger effect. It includes three steps: reducing Cyber threat exposure by $\Delta K_1 = -0.1$ through enhanced security measures, improving Infrastructure by $\Delta K_2 = +0.1$ with more diversification and backup systems, and strengthening Finances by $\Delta K_3 = +0.1$ by building reserves. Each action uses a magnitude of 0.1 , which is half the size used in single-factor scenarios, to reflect realistic improvements that managers can achieve together with typical resources. These three factors were

selected because they represent the three highest-magnitude causal drivers ($D-R > 0$) that management can

directly influence, making them the logical focus for an integrated resilience strategy.

Table 4

Impact of impulses on integral resilience			
Scenario	Impulse	ΔR	Interpretation
S1	$\Delta K_1 = +0.2$	-0.156	Increased cyberattacks reduce resilience by 15.6%
S2	$\Delta K_2 = +0.2$	+0.142	Infrastructure improvement increases resilience by 14.2%
S3	$\Delta K_3 = +0.2$	+0.118	Financial resource growth increases resilience by 11.8%
S4	$\Delta K_1 = -0.2$	+0.148	Reduced cyber threats increase resilience by 14.8%
S5	Combined*	+0.245	Comprehensive improvement increases resilience by 24.5%

*Combined scenario: $\Delta K_1 = -0.1$, $\Delta K_2 = +0.1$, $\Delta K_3 = +0.1$.

Source: Authors' impulse modeling simulations.

Sensitivity Analysis. The sensitivity analysis further reinforced the dominant role of Cyber threats (K_1). Variations of $\pm 10\%$ in its connection weight resulted in an 18–22% change in the resilience outcome (ΔR) in relevant scenarios, confirming it as the most sensitive and critical parameter in the model.

Discussion and conclusions

The obtained results confirm the critical role of cybersecurity in enhancing the resilience of high-tech companies under current conditions. The dominance of the "Cyber threats" factor ($|w| = 0.32$) aligns with data from Opatska, Gajić and Kaščelan (2024), which indicates that 78% of Ukrainian IT companies consider cyberattacks the greatest threat during martial law.

The identification of "Human capital" and "Managerial flexibility" as effect factors ($D - R < 0$) corresponds to Duchek's (2020) theoretical model, according to which adaptive capabilities are formed under the influence of the enterprise's resource base.

The multiplicative effect of cyber threats, revealed through impulse modeling, confirms the need for a systematic approach to ensuring resilience, as described in works by Dahmen (2023) and Settembre-Blundo et al. (2021).

A comparison with classical risk assessment approaches highlights several advantages of using fuzzy cognitive maps:

1. Accounting for nonlinear relationships and feedback loops.
2. Ability to work with qualitative expert assessments.
3. Dynamic scenario modeling.

This research has several limitations that future work should address. First, the expert sample size ($n=10$) represents a constraint, though the high concordance coefficient ($W = 0.864$) suggests this sample achieved reliable consensus. Future research could expand to 20–30 experts across multiple countries to test model generalizability beyond the Ukrainian context.

Second, focusing only on the IT sector means the findings may not apply to other industries. Companies in manufacturing, logistics, or financial services have different risks and resources. A promising approach would be hierarchical fuzzy cognitive maps (Xirogiannis, Glykas & Staikouras, 2010) with sector-specific sub-models nested within a general resilience framework.

Third, the model uses fixed weight coefficients, but real-world relationships between factors can change over time. To improve this, future research should collect data over longer periods and regularly update expert assessments. Adaptive algorithms could then adjust the weights as new data arrives. Machine learning methods, such as recurrent neural networks, could help the model learn how these weights change during different crises.

Finally, the model has not yet been tested with large-scale quantitative data. Future research should collect objective resilience metrics (system downtime, financial impact,

recovery time) from 50+ companies over multiple crisis events to validate model predictions against actual outcomes.

The results directly address the study's main goal. An integrated FCM model for assessing resilience was developed and validated, key factors were identified using quantitative analysis, and practical management strategies were outlined. The model also uncovered patterns that are not immediately obvious. For example, when interventions were combined, the improvement was 24.5%, which is greater than what would be expected if the effects were simply added together. This shows the model's value goes beyond just identifying important factors.

Key Scientific Results:

1. Adapted fuzzy DEMATEL methodology for determining FCM weight coefficients in the context of organizational resilience.

2. Empirically confirmed the dominant role of cyber threats (-0.32) in forming high-tech company vulnerability.

3. Revealed the structure of cause-and-effect relationships: infrastructure and resource factors act as drivers, while organizational capabilities are results.

Practical Implications:

The model can be used for:

- prioritizing investments in resilience enhancement;
- scenario planning of anti-crisis measures;
- optimizing resource allocation between protection areas;
- real-time resilience dynamics monitoring.

Management Recommendations:

1. Cybersecurity – priority #1: investments in Security Operations Center (SOC), critical systems backup, personnel training.

2. Infrastructure independence: autonomous energy sources, communication channel duplication.

3. Financial cushion: 3–6 months operational expense reserves.

4. Personnel policy: retention programs, cross-functional training.

5. Agile management: decision decentralization, scenario planning.

Further Research Directions:

- model expansion with additional factors (reputation, ecosystem connections);
- dynamic adaptation of weight coefficients based on machine learning;
- validation on empirical data from various industries;
- integration with business analytics systems for real-time monitoring.

This research offers a key step forward by turning proactive resilience management into a practical process using predictive scenario modeling. Traditional resilience methods are mostly reactive; organizations deal with crises after they happen and learn from those tough experiences. The fuzzy cognitive map framework introduced here helps organizations prepare in

advance by measuring possible future outcomes before they occur. Managers can test different strategies, such as investing in cybersecurity, upgrading infrastructure, or setting financial reserves, to see how these choices might improve resilience. This approach supports resource decisions based on evidence rather than intuition.

For Ukrainian businesses operating under permanent crisis conditions, and for more organizations around the world facing growing challenges, moving from reactive to proactive resilience management is not just helpful - it is existential. The model provides a practical tool for the transition, bridging academic theory and operational practice.

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НЕЧІТКІ КОГНІТИВНІ КАРТИ СТІЙКОСТІ ВИСОКОТЕХНОЛОГІЧНИХ КОМПАНІЙ

Вступ. Актуальність. Сучасні високотехнологічні компанії стикаються зі зростаючою невизначеністю та комплексними загрозами, такими як кібератаки, руйнування інфраструктури та кадрові виклики. Забезпечення стійкості зазначених підприємств стає критично важливим завданням для національної економіки. Мета статті – розробити когнітивну модель оцінювання стійкості високотехнологічних компаній в умовах комплексних загроз на основі нечітких когнітивних карт.

Методи. Використано метод нечітких когнітивних карт (НЧК) у поєднанні з fuzzy DEMATEL для визначення вагових коефіцієнтів факторів. Проведено експертне опитування 10 топменеджерів для оцінювання взаємозв'язків між факторами. Узгодженість експертних оцінок перевірено за допомогою коефіцієнта конкордації Кендала ($W = 0,864$, $p < 0,01$). Застосовано імпульсне моделювання для аналізу динаміки системи.

Результати. Отримана нечітка когнітивна карта (FCM), із вагами, визначеними за методом Fuzzy DEMATEL, виявила кіберзагрози як найкритичніший негативний фактор (–0.32), а фізичну інфраструктуру – як ключовий позитивний фактор (+0.28), що впливає на загальну стійкість компанії.

Висновки. Запропонована модель демонструє, як різні фактори впливають на стійкість компанії, та допомагає менеджерам визначити чіткі пріоритети. На практиці модель може використовуватися для моделювання кризових сценаріїв та оптимізації розподілу ресурсів для підвищення результативності бізнесу.

Ключові слова: нечітка когнітивна карта, нечіткий DEMATEL, стійкість підприємства, імпульсне моделювання.

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INTERNAL MARKETING AS A STRATEGIC TOOL FOR DEVELOPING INNOVATIVE AND MANAGERIAL POTENTIAL AND ENHANCING THE COMPETITIVENESS OF BUSINESS ENTITIES

Background. Internal marketing is now viewed as a comprehensive system of partnership-based relations that fosters the development of corporate culture, employee loyalty, and customer orientation. This approach increases employee satisfaction, reduces resistance to organizational change, promotes interdepartmental synergy, and contributes to the achievement of the strategic objectives of the economic entity. The relevance of this topic stems from the ongoing transformation of economic conditions, the growing significance of human capital, and the increasing necessity for strengthening internal organizational interactions.

Methods. To generalize the stages of internal marketing evolution and to formulate the authors' approach to defining it, the methods of induction and deduction, along with a comprehensive approach, were employed. To examine scientific approaches to the interpretation of internal marketing and to identify interconnections among elements of the personnel management system, methods of analysis and synthesis were used. Additionally, to construct a conceptual model of internal marketing as an integrated system of interaction, methods of abstraction, logical generalization, and a systemic approach were applied. The study's information base comprised scientific works by foreign and domestic scholars on service marketing, personnel management, organizational behaviour, and internal communications. It also included analytical materials and methodological sources reflecting contemporary approaches to implementing internal marketing in economic entities.

Results. The article substantiates the evolution of approaches to defining the essence of internal marketing within economic entities, as well as its role in shaping an effective personnel management system and influencing organizational behavior. It establishes that modern interpretations of internal marketing encompass not only activities related to attracting, training, and motivating personnel but also the development of communication systems, the formation of a value set-up, corporate philosophy, and culture. The authors propose a definition of internal marketing based on the identified key principles, factors, and functions, and present a model of internal marketing for an economic entity. This model is based on elements of the classical marketing "4P" framework and encompasses components such as planning, communications, control, and reputation management, among others.

Conclusions. The conducted research enabled the authors to define internal marketing as an integrated system of partnership relations in human resource management. This system focuses on creating and maintaining a motivational climate and organizational working conditions within the economic entity to ensure customer orientation and employee loyalty. In this framework, employees not only perform functions aimed at improving service quality and meeting the needs and demands of the customers but also actively participate in implementing corporate philosophy, values, and strategies to achieve objectives and maintain a positive company image. A conceptual model of internal marketing is proposed as a human resource management mechanism that integrates motivational, communicative, organizational, and cultural components within the economic entity.

Keywords: HR-marketing, human resource management, organizational culture, personnel engagement, consumer, stakeholder, service quality, partnership relations.

Background

Relevance of the study. In the current environment of rapid economic transformations, labour market instability, digitalization of business processes, and increasing competition, the issue of effective human resource management has become particularly pertinent. An increasing number of companies recognize personnel not merely as a resource, but as a key strategic asset, upon whose satisfaction, motivation, and engagement the competitiveness and sustainability of the organization largely depend. Against this backdrop, interest in internal marketing as a tool to harmonize intra-organizational relations, foster a favourable microclimate, ensure internal loyalty, realize innovative and managerial potentials, and enhance the quality of external service is growing.

The concept of internal marketing originated in the 1970s within the service sector; however, over time, it has evolved

into a universal paradigm applicable across various industries. Its core principle lies in treating employees as internal customers and work as an internal product that must be attractive, valuable, and aligned with employee expectations. Concurrently, traditional marketing principles – value, communication, service, and motivation – are applied within the internal environment of the organization.

Despite the widespread adoption of internal marketing practices among leading companies, there remains no universally accepted definition of the concept within domestic scholarly literature, and approaches to its structural framework are fragmented. This lack of consensus complicates both its effective implementation and the assessment of its impact within personnel management systems. Therefore, there is a pressing need to revisit the evolution of the internal marketing concept, to systematize its approaches and functions, and to define its

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role within the management model of economic entities. It is crucial to substantiate internal marketing as a system of partnership relations encompassing not only personnel but also all key internal stakeholders of the organization. The adaptation of the classical "4P" marketing model to the internal environment of enterprises is also relevant, as it enables the customization of external marketing tools to meet organizational management needs.

The purpose of this article is to clarify the essence and conceptual model of internal marketing by examining its evolution as a scientific concept, identifying its key principles, factors, and functions, and thereby forming a comprehensive understanding of internal marketing as an integrated human resource management system that fosters enhanced motivation, employee engagement, and customer-oriented organizational behaviour within economic entities. **The object of this study** is the personnel management processes within economic entities that implement marketing approaches in their interactions with internal stakeholders. **The subject of the study** encompasses the conceptual foundations, principles, and functions of internal marketing as a tool for shaping effective organizational behaviour and fostering internal customer orientation within economic entities.

Literature review. Numerous foreign and domestic scientists have made significant contributions to the development of the internal marketing concept, developing it from initial ideas to a multifaceted philosophy and management toolkit. For example, Berry L. defined internal marketing as motivating employees through marketing activities, later expanding this definition to view internal marketing as a philosophy of treating employees as internal customers and as a strategy for creating a "work product" tailored to the needs of the employee-customer (Berry, 1981).

Gummesson E. emphasized the importance of relationships in the internal marketing system, identifying seven levels of "nano-relationships" that can be perceived as aspects of internal marketing (Gummesson, 1991).

Grönroos C. proposed considering internal marketing through the prism of total quality management of customer service, first introducing the terms "internal product" and "internal consumer", and presenting internal marketing as a management philosophy that continuously encourages and reinforces the understanding and appreciation of personnel roles within the organization. Its goal is to attract and retain customer-oriented employees, as well as to develop and maintain a service culture (Grönroos, 1985). As Sahaidak M. notes, the scientist, together with P. Voima, interpreted internal marketing as a cumulative concept encompassing many internal activities at various levels, defining it as the process of establishing and maintaining relationships with employees and other internal consumers to satisfy the needs of all parties involved (Sahaidak, 2016).

Rafiq M. defined internal marketing as an activity aimed at implementing a change management strategy and developed an internal marketing model comprising five factors: personnel motivation and satisfaction, customer orientation, cross-functional coordination and integration, application of traditional marketing, and implementation of corporate strategies. They argued that internal marketing contributes to the effective execution of corporate strategies. Additionally, they structured the elements of the traditional marketing toolkit "4P" in relation to internal markets, forming an "internal marketing mix", and proposed expanding it to "7P". Furthermore, they conducted a critical analysis of the internal marketing concept and developed criteria for

evaluating the effectiveness of internal marketing programs (Rafiq, 1993).

Lings I. proposed a philosophy of internal marketing in which personnel are simultaneously regarded as a vital resource for achieving company goals and as the most important group of internal clients whose needs must be satisfied. His perspective contributed to understanding internal marketing not merely as a functional activity but as a business approach grounded in internal marketing research, communication, and responsiveness (Lings, 1999).

Kotler P. included internal marketing as one of the components of the holistic marketing concept; he characterized it as a two-level system: the first level implements various marketing functions, and the second – integrated marketing, where other departments "think from the buyer's perspective"; he identified three interconnected units in the activities of service enterprises (enterprise, contact personnel and consumer), which form three links of relationships, where the internal marketing strategy is aimed at the "enterprise-personnel" link, related to personnel motivation (Kotler, 1999; Kotler, & Keller, 2012).

Drucker P. believed that internal marketing should be aimed at the company's reputation to attract employees, as well as at the position of marketing in the company, and noted that "managing people is 'marketing work'", suggesting to consider employees as "volunteers" due to the limited financial motivational tools (Drucker, 2012).

Kapferer J.-N. introduced branding into the scope of internal marketing, emphasizing that branding experience in the service sector is closely linked to the points of contact between customers and personnel. He noted that internal marketing is essential for managing brand contact, which requires consistency in functional responsibilities as well as shared accountability of management and personnel for the promises and unity embodied by the brand (Kapferer, 2008).

Ballantyne D. identified the main principles of internal marketing: orientation to satisfying personnel needs, motivating all personnel to consciously satisfy the needs of external consumers, using traditional marketing methods within the organization, cross-functional cooperation, active interaction, and readiness for change. In addition, he noted that this approach allows reducing the gap between theoretical justification and practical implementation (Ballantyne, 2000).

Voichak A. used the term "internal marketing management" and proposed an author's classification of the internal marketing concept depending on the internal market, paying significant attention to research on the structure and role of internal communications. He believed that internal marketing is aimed at ensuring full perception of marketing principles by all enterprise personnel, especially its management (Voichak, 2009).

Kudenko N. characterized internal marketing from the perspective of its strategic value for the enterprise, where the object of research is personnel in the process of implementing a marketing strategy as "the enterprise's internal market" and substantiated the similarity of internal marketing with the postulates of personnel management theory in terms of strategic business partnership (Kudenko, 2012).

Reshetnikova I. defined internal marketing as activity within the enterprise aimed at creating a favourable internal environment, conveying enterprise values and its marketing goals to management and personnel, training contact personnel for the best satisfaction of consumer needs and increasing the customer base, and emphasized that internal marketing should cover the integration of efforts, setting up

the service process, creating material conditions, and training personnel (Reshetnikova, 2015).

Okuneva O. noted that internal marketing should be considered from the perspective of service quality, internal communications, innovation implementation, the organization's internal market, and the implementation of marketing plans; she defined the internal marketing system as a set of interconnected and interdependent elements of the internal marketing complex and targeted management actions for the development and retention of customer-oriented contact personnel for the best satisfaction of the end consumer's needs; she developed an internal marketing complex "8P", which, unlike the classical "7P", is supplemented with the element "prolonged service productivity" to account for the differences in providing and consuming services (Okuneva, 2014).

Kosar N., Sarapin T., Kuzio N. emphasized that internal marketing, as a component of holistic marketing, ensures the acceptance of marketing principles by all employees and regulates relations at the "company – personnel" level (Kosar, Sarapin, & Kuzio, 2013).

Mishustina T. called internal marketing a new direction of marketing activity, whose task is to create a customer-oriented environment within the organization (Mishustina, 2014).

Sahaidak M. proposed an author's definition of internal marketing as "activity aimed at building mutually beneficial partnership relations in the value creation chain owner – top manager – personnel – client with the aim of best satisfying the needs of internal and external consumers and achieving the market and social goals of the enterprise" (Sahaidak, 2016).

Vengerova O. substantiated a five-stage approach to implementing internal marketing at the enterprise, aimed at increasing personnel productivity and overall enterprise efficiency, emphasizing the importance of internal communication and knowledge management (through the SECI model and "knowledge spiral") for achieving market goals and increasing management efficiency (Vengerova, 2018).

Krasovska O. emphasized that corporate culture is an integral part of internal marketing, which directly affects the efficiency of employees, creating a favourable internal climate and providing the company with competitive advantages in the market, emphasizing that balanced internal marketing criteria can optimize the working environment and improve the quality of customer service (Krasovska, 2021).

Thus, the authors' contribution to the development of the internal marketing concept lies in the consistent expansion of its interpretation, from basic personnel motivation to a comprehensive management system that integrates HR functions, corporate culture, change management, branding, and a focus on the internal customer as a key success factor in the external market. However, despite significant progress in the scientific literature, there is still a lack of generalized approaches and models of internal marketing that take into account contemporary challenges and the dynamic changes in the internal environment of economic entities. Comprehensive research into the principles, factors, and functions of internal marketing, as well as their systematization within a unified conceptual framework, requires further development.

Methods

The study employed a range of general scientific and specific research methods. To generalize the stages in the evolution of internal marketing and to formulate the author's definition, the methods of induction, deduction, and a comprehensive approach were applied. These enabled the identification of five key phases in the development of the

internal marketing concept: from a focus on personnel motivation to the understanding of internal marketing as an integrated component of the economic entity's management system, ensuring the interconnection between human resource management, corporate culture, and overall marketing strategy. To examine scientific approaches to interpreting internal marketing and to reveal interconnections between elements of the human resource management system, the methods of analysis and synthesis were used. This facilitated the structuring of existing concepts and provided a rationale for considering internal marketing as an integrated human resource management system that enhances motivation, promotes employee engagement, and ensures customer-oriented organizational behaviour in economic entities. To construct a conceptual model of internal marketing, the methods of abstraction, logical generalization, and a systems approach were applied. These made it possible to form a comprehensive view of internal marketing as a human resource management mechanism that integrates motivational, communicative, organizational, and cultural components within the economic entity. The informational foundation of the research was formed by the scientific works of both foreign and domestic scholars in the fields of services marketing, human resource management, organizational behaviour, and internal communications, as well as by analytical materials and methodological sources reflecting modern approaches to the implementation of internal marketing in economic entities.

Results

In the context of modern economic transformations, innovative approaches to managing economic entities and their market activities are receiving growing attention. Since the late twentieth century, internal marketing has emerged as a topic of particular interest, increasingly generating debate and contradictions among marketing theorists and practitioners. At the same time, the concept of internal marketing has undergone several distinct phases of development (Lytvynenko, 2019; Sahaidak, 2016):

1. In the first phase, in 1970–1980 (focus on service marketing), researchers concentrated primarily on employee job satisfaction and workplace comfort. Internal marketing was understood as the process of attracting, training, motivating, and retaining qualified personnel by creating working conditions that met their needs. In this context, employees were regarded as consumers of the services and benefits offered by the organization's human resource management system. A strong focus was placed on material incentives and rewards as key tools for encouraging effective performance. Thus, the term "internal marketing" first appears from the representative of the American School of Services Marketing Berry L. and is defined as "applying the philosophy and practice of marketing to people (specialists) who serve external customers for the purpose of hiring and retaining the best personnel and ensuring they perform the highest quality work" (Berry, 1981). The key thesis in this approach is: "to satisfy the consumer, the economic entity must first satisfy the employee" (George, 1977; Sasser & Arbeit, 1976). Thus, according to L. Berry, "internal marketing is attracting, developing, motivating and retaining qualified personnel through work that is offered and satisfies the needs of the worker". Therefore, on the one hand, "internal marketing" is viewed as a philosophy of the employer's attitude towards personnel as an internal client, and on the other hand, as a strategy for creating a work-product in accordance with the needs of the employee-client (Sahaidak, 2016). And all actions primarily concern contact personnel.

2. In the second phase (1980–1990), Grönroos C., a leading figure of the Scandinavian school of services marketing, exerted a decisive influence on the development of internal marketing. He argued that, in delivering quality services, both frontline personnel and support staff (those who do not directly interact with clients) play a crucial role. Grönroos C. emphasized that consumer orientation among employees is best achieved through targeted marketing influence—applying a client-influence model—rather than merely by satisfying and stimulating staff. Consequently, he expanded the definition of internal marketing from a mere personnel-motivation technique to a strategy for fostering customer and sales orientation. As he put it: "The internal market of employees of an economic entity can be influenced more effectively and, therefore, stimulate customer-orientation, market orientation, and sales through the implementation of marketing activities directed inside the economic entity" (Grönroos, 1985). However, like L. Berry's concept, Grönroos's approach focuses on shaping employee customer orientation via influence processes, rather than on enhancing their satisfaction and motivation.

3. The beginning of the third phase (1990–2000) was marked by many authors' understandings of internal marketing as a means of implementing the economic entity's strategy. Winter J. argues that the role of internal marketing is to target, train, and motivate personnel to fulfil the institutional objectives of the economic entity. In his view, internal marketing is a process through which employees come to understand and acknowledge not only the value of the program but also their role within it (Winter, 1985). In this phase, the role of internal marketing as a tool or methodology for implementing the economic entity's strategy becomes clearer. Initially, this viewpoint appeared in the context of service provision. Later, it was generalized to any type of marketing strategy. Thus, both researchers and practitioners have recognized the significant role of internal marketing as a technology for human resource management aimed at achieving the strategic objectives of an economic entity. Internal marketing functions as an interfunctional unifying mechanism within the organization, playing a crucial role in integrating marketing and HR functions. Consequently, personnel are transformed into a strategic resource that actively contributes to the implementation of marketing processes.

4. In the fourth phase (2000–2010), internal marketing began to be viewed as a mechanism for reducing departmentalization, interfunctional resistance, and overcoming resistance to change. This phase of development leads to the conclusion that the scope of internal marketing is much broader than just employee motivation and customer orientation. Internal marketing researchers Ahmed K. P. and Rafiq M. considered the latest transformations in the understanding of internal marketing and gave it the following definition: "It is planned efforts to overcome organizational resistance to change and to direct, motivate, and integrate employees for effective implementation of corporate and functional strategies" (Rafiq & Ahmed, 1993). This definition implies that any strategic change is likely to necessitate internal marketing efforts aimed at overcoming organizational inertia and motivating employees to adopt the desired behaviours. In addition, since some (including marketing) strategies are likely to encompass several functional areas, this process will likely require cross-functional integration. The above definition of internal marketing takes this aspect into account and shifts the focus from viewing the employee as a

customer to emphasizing the tasks and measures necessary for the effective implementation of marketing and other organizational programs aimed at achieving customer satisfaction, while recognizing the central role of employees.

5. In the fifth phase (2010 – present), internal marketing is considered as a system of partnership relations and an integrated management function in the chain of participants: "owner – top manager – manager – personnel – contact personnel – consumer".

Therefore, it should be emphasized that internal marketing is important not only for the service sector. It is also relevant for economic entities in various industries (e.g., information technology), where the final product largely depends on the potential of personnel and their motivation in the production process. Thus, the emphasis on the philosophy of building relationships with personnel, particularly frontline or contact employees, as partners forms the foundation of the modern concept of internal marketing, which identifies three categories of consumers:

- internal consumers (personnel);

- stakeholders (interested groups or individuals who can influence the company's achievement of its goals or are themselves influenced by this process, i.e., business owners, top managers, partners);

- external consumers (end-users). It should be noted that internal marketing is sometimes equated in literary sources with such concepts as intra-firm, intra-corporate, or intra-market marketing. Such a vision of the essence of internal marketing by various scholars is associated with:

- 1) the extension of marketing principles and methods to all levels of management of the economic entity and the improvement of internal organizational processes;

- 2) the strengthening of the interaction of intra-corporate marketing with the HR department in terms of such activities as recruitment, selection, certification, and professional development of personnel, and the strengthening of the role of intra-corporate communications and PR events;

- 3) the consideration of personnel and structural subdivisions of the economic entity as an internal market, where there is an exchange of work-product (provision of a workplace and satisfaction of personnel needs) and the results of personnel work (standards of quality service for external target consumers).

At the current stage of development, the concept of "internal marketing" can be considered from the following perspectives:

1. Internal marketing as a system of relationships with contact personnel refers to the activity of an economic entity directed at various target groups of current employees. Its purpose is to identify their needs, expectations, and level of satisfaction with working conditions, as well as prospects for professional and career development. In this context, internal marketing primarily functions as a relationship system focused on contact personnel, aiming to enhance service quality by creating motivational and organizational working conditions. These outcomes are achieved through the formulation and implementation of strategic goals and tasks, utilizing selected elements of the internal marketing system (Kudenko, 2012; Mazur, & Bratko, 2016). That is, before a high-quality service can be delivered to an external customer, it must first be "sold" to the internal customer – the personnel. In other words, employees must be consciously motivated to uphold quality standards in external customer service. In this interpretation, internal marketing is viewed primarily as a set of efforts directed at contact personnel, and its scope significantly overlaps with

that of human resource (HR) management. At the same time, the main focus of internal marketing within the economic entity remains the "contact" personnel. It is important to emphasize that HR specialists should be responsible for the selection and overall qualification development of personnel, whereas marketing management should focus on training employees in marketing techniques, communicating the organization's values and objectives, familiarizing them with product and service characteristics, and applying sales promotion tools – similar to those used when working with external intermediaries (Reshetnikova, 2015). Contact personnel can include individual employees, their groups, or all personnel directly or indirectly involved in change processes and/or the implementation of marketing strategies and programs, i.e., all those who make contact with the target and contact audiences of the economic entity:

- 1) top managers who hold meetings and establish contacts with interested audiences;
- 2) employees of the marketing and sales department who communicate with intermediaries and suppliers;
- 3) specialists of the advertising department who contact representatives of television and radio companies, advertising and information, and PR agencies;
- 4) IT department specialists who maintain communication with existing and potential clients using the economic entity's website electronic resources;
- 5) accountants who report on the economic entity's activities to the tax inspectorate and control and audit bodies, as well as those who interact with representatives of banking institutions, also belong to the category of contact personnel. In the service sector, this category typically includes staff or specialists who directly deliver services to consumers. These professionals act as intermediaries in the process of transferring services to end users. Such intermediation involves balancing the interests of business owners, external customers, and other stakeholders, along with their professional interests. Importantly, contact personnel cannot fully realize their interests, whether commercial or non-commercial, without first satisfying the interests of the consumer or other counterparties. These individuals must understand the value and characteristics of the goods or services offered and be properly motivated to deliver high-quality service. Therefore, top management should view and treat contact personnel as strategic partners. In this context, contact personnel can be understood as customer-oriented managers and specialists of the economic entity who establish and maintain long-term, mutually beneficial relationships with both internal and external contact audiences in order to achieve the marketing goals of the organization (Sahaidak, 2016).

2. Internal marketing as a process of forming customer-oriented personnel is a process that takes place within the economic entity at all functional levels, motivates and inspires personnel at all management levels, to improve the quality of customer service (Organ, Podsakoff & Mac Kenzie, 2006). That is, it is an attitude towards one's employee as an internal client, and its goal is to ensure working conditions that meet the needs of the personnel. By creating proper working conditions, imposing the values and beliefs of the economic entity on the personnel, and using marketing tools, the result is achieved in the form of a customer-oriented employee.

3. Internal marketing as a philosophy of human resource management of an economic entity is considered the creation of such favourable conditions and relationships within the economic entity that would ensure effective work

and interaction of all personnel, and high satisfaction of employees as internal clients. The result of internal marketing is a level of personnel loyalty that ensures a dedicated and sincere attitude towards employees, management, other persons, their actions, and the economic entity as a whole; it encourages employees to consciously perform professional tasks and duties at a high level in accordance with the goals and interests of the economic entity, and evokes the desire of each employee for initiative, active activity to improve its results.

4. Internal marketing as a system of internal company communications is a form of marketing within an economic entity that focuses personnel's attention on internal actions that must be changed to improve the economic entity's market position (Yeriomina, 2020).

5. Internal marketing as a tool for implementing corporate and functional strategies is understood as the application of a marketing approach to employees. It involves building, stimulating, coordinating, and integrating personnel to ensure the effective implementation of strategic objectives. This process aims to satisfy the end consumer through interaction with motivated and customer-oriented staff.

It should be noted that economic entities with many professional employees, as well as with an extensive network of branches and departments, have the greatest need for internal marketing. This is since professional employees are usually not inclined to consider themselves as subordinates (they cannot simply be given orders), they are significantly less dependent on economic entities, and more committed to their field of knowledge than to the economic entity itself.

Thus, the following conclusions can be drawn:

1. All listed approaches focus on the internal client – the employees of the economic entity.
2. The main goal of internal marketing is to create favourable working conditions that ensure high motivation, satisfaction, and loyalty of personnel. This is achieved through creating a favourable working environment, supporting professional growth, and integrating corporate values.
3. An important element is the integration of the efforts of various departments of the economic entity (HR, marketing, management) to ensure coordinated actions aimed at maintaining corporate culture and implementing strategies.
4. Despite the primary focus on the internal client, the goal of all approaches is to improve the quality of external customer service through personnel training and motivation.
5. First and foremost, it is essential to create working conditions that meet the needs and expectations of employees, as this directly influences their productivity and loyalty to the economic entity. The link between the quality of services provided and external customer satisfaction on the one hand, and the satisfaction of internal customers (i.e., personnel) on the other, is both evident and well-established (Fig. 1).

Thus, internal marketing serves as a key instrument in establishing an effective human resource management system and shaping organizational behaviour. It facilitates the creation of conditions in which employees not only comprehend the goals and values of the economic entity but also actively contribute to their achievement, thereby enhancing the overall efficiency of the entity and increasing the satisfaction of external clients. Considering various approaches and views, internal marketing is proposed to be understood as an integrated system of partnership relations for human resource management, which is focused on creating and maintaining a motivational climate and organizational working conditions within the economic entity to ensure customer orientation and personnel loyalty, where

employees act not only as performers of functions to improve the quality of service for external clients and satisfy their needs and requests, but also as active participants in

the implementation of corporate philosophy, values and strategies to achieve goals and form and maintain a positive image of the economic entity.

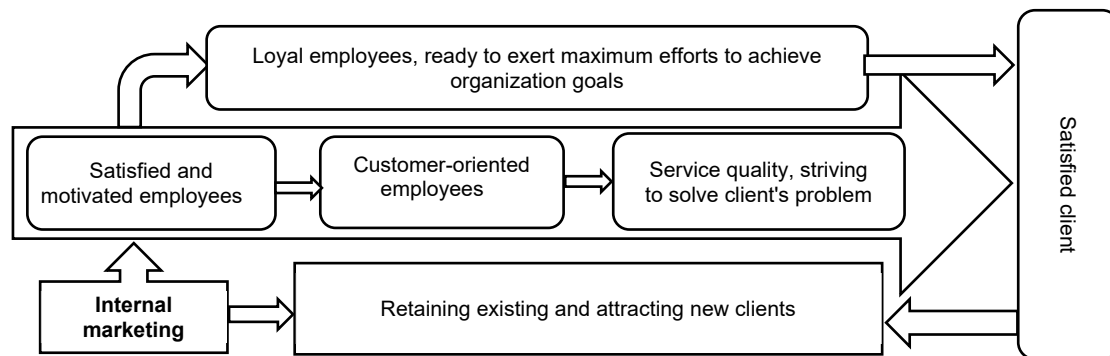


Fig. 1. The chain of service quality assurance in internal marketing

Source: formed on (Lings, 1999; Sahaidak, 2016).

Therefore, internal marketing should be considered as:

- 1) a system of relationships between the economic entity and its personnel, which cannot exist separately from each other;
- 2) an internal philosophy of market orientation;
- 3) a component of corporate philosophy and culture implementation, and the formation of the economic entity's strategy;
- 4) a tool for improving product (service) quality and the economic entity's image. In addition, it should be noted that the concept of internal marketing is based on elements of the traditional complex by analogy with traditional marketing and McCartney's marketing concept model "4P" (Kudenko, 2012), from which internal marketing programs are formed at both the top management level and in departmental management or personnel promotion (Mazur, & Bratko, 2016).

The first and fundamental element of any marketing mix is the product. In the context of internal marketing, the job offered by the economic entity to the employee represents the internal product. The development of this internal product (the job) encompasses the following elements (Flipo, 1986):

- selection of appropriate personnel;
- effective internal training;
- proper distribution of powers and responsibilities;
- creation of conditions for teamwork.

The second element of the internal marketing mix is price. Payment is the price of the internal product. It should be noted that the internal marketing "price" is not equivalent to the salary paid by the economic entity to its employees as compensation for their labour, but rather "what we demand from our internal clients as 'payment' when they 'buy' the product and participate in the marketing plan". The determination of the price of the internal product is based on the premise that the benefits employees derive from the job must exceed their opportunity cost. In other words, employees should perceive that the material, social, and other benefits they receive in their current position surpass those available in alternative employment. Only under such conditions can the economic entity expect to retain satisfied personnel who perform quality work.

The third element of the internal marketing complex is place or so-called "distribution". Place (distribution) is the way of delivering the internal product to its consumer (employee). The term "internal marketing place" can be understood as a set of spaces, processes, people, and decisions (managerial, technological, etc.) within a specific

organizational structure and corporate culture that form a platform for "economic entity-employee" relationships in the process of achieving the economic entity's strategic goals and ensure the reliability, openness, and transparency of these mutual relationships.

The fourth element of the internal marketing complex is promotion, which is most visibly manifested in the form of internal communications and appeals. Promotion of the internal product is the formation of corporate culture, contributes to meeting the needs of internal clients, creating a system of effective relationships between internal clients and internal suppliers, between internal clients and external clients, developing internal communications, and other elements of internal PR. Internal marketing focuses on relationships and processes within the economic entity (Mazur, & Bratko, 2016).

The methodological basis of internal marketing as a science includes the following approaches:

- 1) systemic – viewing processes as systems, i.e., combining elements necessary for forming internal marketing and achieving a specific goal into a single whole;
- 2) complex – as a unity of organizational, economic, social, legal, psychological, and other aspects of management;
- 3) situational (applied) – the actions of the economic entity and its manager must depend on the current state of the internal and external environment (context) of the economic entity.

Based on the generalization of various scientific approaches (see above), the main principles of internal marketing of economic entities are (Sahaidak, 2016):

- 1) entering the market with an individual service offer and ensuring a high level of customer service and additional services;
- 2) establishing mutually beneficial cooperation with employees of the economic entity as business partners, by creating proper working conditions, motivating and satisfying needs in exchange for their professional qualities and intellectual abilities to achieve the corporate goals of the economic entity;
- 3) forming and implementing a change management strategy by developing marketing programs, defining the role and place of personnel in them, and implementing tactics of active service offering, taking into account the values of the internal and external market, and simultaneously influencing it;
- 4) ensuring compliance of the desired result from receiving and consuming the service by the client, forming

loyalty (of personnel and clients) to the economic entity and its brand, as well as a positive consumer experience.

Domestic and foreign researchers identify five main factors of internal marketing (Kosmyna, 2012):

- personnel motivation and satisfaction;
- customer orientation and their satisfaction level;
- organizational integration and coordination;
- marketing approach to organizational behaviour;
- implementation of corporate and functional strategies of the economic entity.

Regarding the main advantages of internal marketing's influence on organizational behaviour, the following can be highlighted (Ahmed, & Rafiq, 2002):

- 1) encouraging personnel to productive work;
- 2) empowering personnel with certain responsibilities;
- 3) encouraging personnel to provide quality customer service;
- 4) improving understanding of marketing principles by all employees;
- 5) improving customer satisfaction and loyalty;
- 6) integrating business culture, human resource management structure, vision, and strategy with professional and social needs of personnel;
- 7) creating effective coordination and communication between departments and subdivisions, ensuring proper information flow within the economic entity (Leskiv, & Bochko, 2014).

The formation of an effective internal marketing system can be conditionally divided into the following processes, which are not one-time:

- researching market requirements regarding personnel qualities;
- recruiting and training employees;
- researching employee needs and offering them an "internal product" (work) that would maximally satisfy their needs;
- conveying and explaining the values and tasks of the economic entity and its marketing goals;
- training the contact personnel of the economic entity on product properties and characteristics, sales methods and techniques to best satisfy consumer needs, and increase the economic entity's customer base, etc. In this context, regarding relations with the personnel of the economic entity, the following functions of internal marketing can be distinguished:

1. *Functions related to the formation and management of customer-oriented contact personnel* (Sahaidak, 2016):

- 1) selling the "internal product" to the economic entity's contact personnel, as an internal consumer;
- 2) comprehensive study of the internal consumer, their needs, requests, desires, and satisfaction with the performed work;
- 3) segmentation of the internal market where the work-product exchange takes place;
- 4) identifying the individual values of contact personnel and taking them into account in the mission and corporate culture of the economic entity;
- 5) establishing interaction and forming internal interpersonal relationships between the contact personnel of the top office, middle office, and front office;
- 6) internal communication and integration of personnel ("part-time marketers") to satisfy consumer needs and achieve the marketing goals of the economic entity;
- 7) creating conditions and an atmosphere of mutual understanding among employees regarding orientation towards the final result;

- 8) best customer satisfaction;
- 9) increasing customer orientation of contact personnel, etc.

2. *Functions related to the formation and management of customer-oriented personnel in general* (Sahaidak, 2016):

- 1) investigating employee satisfaction with the work performed;
- 2) developing internal corporate service standards and controlling service quality;
- 3) forming a marketing orientation of personnel during training and conducting corporate seminars and training;
- 4) popularizing the products manufactured and services provided by the economic entity by disseminating information about their advantages, production technologies, and other relevant aspects; attracting new customers while retaining and supporting existing ones through loyalty programs; and creating a highly attractive employer brand image. This approach enables employees not only to receive material benefits but also to fully realize their professional competencies and personal qualities.

In general, the functions of internal marketing can be combined into the following 5 groups (Sahaidak, 2016): analytical, integrating, information and communication, stimulating, and managerial.

The implementation of *the analytical function*, using various market analysis tools, ensures the development of well-founded marketing plans at the strategic, tactical, and operational levels. The components of this function are:

- study of the internal and external market;
- study of internal and external consumers;
- study of consumer demand for services;
- analysis of the internal environment of the economic entity.

The integrating function allows for effective, mutually beneficial cooperation between all departments of the economic entity, between personnel and consumers. The focus of this function is the unification of the economic entity's personnel and its preservation as such.

The components of this function are:

- uniting the personnel of the economic entity based on a common cause, a common way of thinking, moral and corporate values, and experience;
- development of a system of horizontal and vertical ties;
- joint participation in the preparation and conduct of corporate events and solving non-standard situations;
- involvement of personnel and service consumers in value creation;
- creating an atmosphere of safety and stability for employees.

The information and communication function in the internal marketing system provides reliable, timely and objective information to all participants in the consumer value chain about the mission, goals and values of the economic entity; about the socially necessary quantity, assortment and quality of goods (services); about the competitive positions of the economic entity in the market and its advantages; about the results of activities and success stories of employees, etc. The components of this function are:

- corporate media, as a public part of the internal communication system and as the most powerful channel of influence;
- direct communications at horizontal and vertical levels (meetings with management, open days, feedback letters);
- promotion and internal public relations;
- organization of advertising and stimulation of consumer preferences.

The *stimulating function* creates guidelines for the development or curtailment of production activities. The task of this function is to ensure the most complete activation of individual performers or labour collectives to achieve clearly formulated goals and set tasks. The stimulating function aims, first of all, to satisfy the economic, social, and moral-emotional interests of personnel in performing their functional duties.

The components of the stimulating function are:

- encouraging the economic entity to reduce costs;
- focusing on motivating personnel to take specific actions and find solutions in resolving non-standard situations;
- motivating personnel to maximize the satisfaction of their own and others' interests;
- improving the quality and consumer value of services;
- establishing new contacts, etc.

The *managerial function* traditionally involves systematic targeted influence on marketing activities through planning, organization, motivation, coordination, and control to achieve defined marketing goals of the economic entity.

Components of this function:

- organization, planning, and control of marketing activities in internal and external markets;
- coordination of actions and motivation of personnel.

When making management decisions, it is essential to ensure the presence and proper functioning of all the above-mentioned functions. Underestimating the importance of any one of these functions in practice can lead to misunderstandings regarding the goals and objectives assigned to individual employees or teams, inconsistencies in actions, a lack of initiative, and frequent violations of labour, executive, and organizational discipline.

The model of internal marketing of economic entities contains the following systematically and comprehensively interconnected elements (Fig. 2).

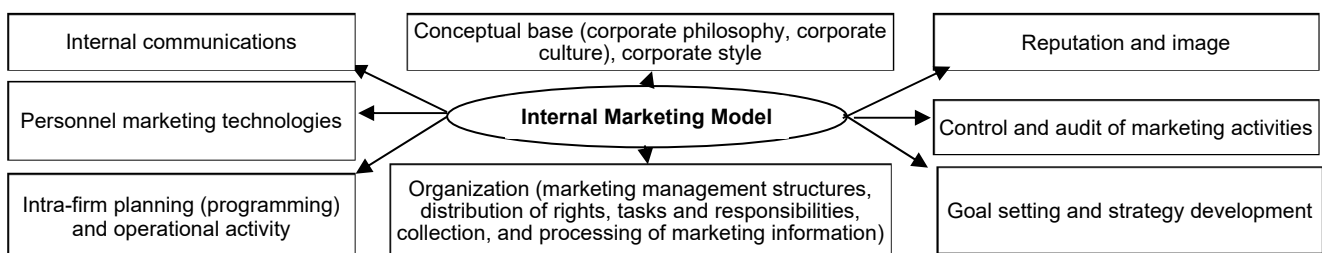


Fig. 2. Elements of the internal marketing model of an economic entity

Source: author's development.

To summarize, internal marketing must be integrated into the organizational behaviour of economic entities. To achieve this, managers need to employ all available methods to foster shared values and beliefs among personnel, ensuring that the concept of the "internal client" is recognized at all levels of the economic entity. Establishing a firm internal conviction that clients exist both inside and outside the organization should become a stable norm adhered to by all employees. As a result, personnel will align their behaviour with these organizational norms, driving positive changes both within the economic entity as a whole and in its organizational behaviour specifically (Kosmyna, 2012).

That is, internal marketing aims at systematic optimization of processes occurring within the economic entity, using methods of HR and marketing management. The object of internal marketing is the employees of the economic entity and the internal environment of the economic entity, viewed through the prism of the client (Leskiv, & Bochko, 2014; Sahaidak, 2016).

Among the main tasks of internal marketing, the following can be distinguished (Sahaidak, 2016):

- 1) simultaneous orientation towards both clients and personnel, studying their needs, taking into account individual values and interests (personnel satisfied with their work can more easily assimilate given service standards and provide higher quality service to external consumers);
- 2) reducing the isolation of the economic entity's subdivisions and interfunctional discrepancies;
- 3) development by the economic entity's management of a favourable microclimate for work, psychological support, assistance, friendly attitude towards personnel, mutual trust and respect;
- 4) overcoming resistance to innovation from personnel (when introducing any innovations, the management of the

economic entity, as a rule, may face difficulties related to personnel (misunderstanding, unwillingness, possibly fear, etc.).

Thus, the core idea of internal marketing is the application of external marketing concepts, ideas, and tools within the internal market of an economic entity, i.e., within its internal organizational environment, which significantly influences overall organizational behaviour. Internal marketing posits that the relationship between an economic entity and its employees mirrors the relationship between the entity and its external clients: the entity offers a "product" (a specific job position) which the employee "acquires" by investing their labour. The traditional marketing focus on customer needs is extended here to include the employee as an "internal" consumer. Internal marketing aims to ensure high product quality at every stage of production and delivery by enhancing employee motivation through satisfaction with working conditions, compensation, team atmosphere, and other factors.

Discussion and conclusions

Our study of the essence and phases of internal marketing development further clarified the results of the systematic review of the role of internal marketing in personnel development and organizational performance, and its role as a mediator between leadership style and market orientation (Hidayati, Suyanto & Istanto, 2023). It also emphasized the importance of involving personnel in developing and understanding organizational goals, which is the essence of internal marketing. Additionally, it highlighted the importance of ensuring that personnel meet qualification and motivational requirements, which include aspects of personnel marketing and enhancing the enterprise's attractiveness in the labour market (Dashko, Bekhter, & Mykhailichenko, 2023).

The model we developed complements the results obtained by scientists Li E. Y. and Ko S.-F., who substantiated the interaction with knowledge integration,

quality of internal communications, and other individual employee factors (Li, & Ko, 2021); Eltayib N. H. E. and Ali A. B. M., who studied the impact of personnel marketing technologies (internal training, motivation, reward), communications on employee satisfaction in the banking sector (Eltayib, & Ali, 2022); Yıldız S. M., who showed the links between internal marketing, engagement, performance, and turnover intention in Turkish sports organizations (Yıldız, 2024); Brahimi A. and Kadri D., who investigated the impact of internal marketing on service quality through the prism of internal communication processes (Brahimi & Kadri, 2024); Awwad M. S. and Lafi F. M., who clarified the role of internal marketing as a mediating variable in path-goal leadership styles and the market orientation (Awwad, & Lafi, 2023); Grishnova O., who presented a model of human capital management based on digital technologies, aimed at improving the internal experience of employees, their engagement, and loyalty through the integration of IT solutions into HR strategies, creating favourable conditions of work, developing digital competencies, and ensuring flexibility, which optimizes interaction between personnel and encourages innovation (Grishnova, 2025); Lisogor L. and Rudenko N. who examined the component structure of human resource potential which includes a motivational component and substantiated the directions for minimizing the risks of its quality deterioration. They emphasized encouraging employers to invest in employee upskilling and enhancing their motivation for self-education, which are key technologies of personnel marketing within the internal marketing model (Lisogor, & Rudenko, 2022).

Based on the above, it is evident that the concept of internal marketing has evolved through five distinct phases, beginning with an initial focus on personnel satisfaction with work in the 1970s–1980s and progressing to a systemic understanding of internal marketing as a system of partnership relations and an integrated management function within the network of organizational participants "owner – top manager – manager – personnel – contact personnel – consumer" in the modern fifth phase (since 2010). Currently, internal marketing serves as a key tool for establishing an efficient human resource management system and shaping organizational behaviour. The core idea is to apply marketing principles to the internal environment by treating employees as "internal clients", where the job is the "internal product" offered by the economic entity, and the employee "purchases" it through their labour. In addition, in the modern fifth phase of development, internal marketing also considers stakeholders (business owners, top managers, and partners) as a separate category of consumers alongside internal (personnel) and external (end) clients.

Considering the above, internal marketing can be understood as an integrated system of partnership relations in human resource management, aimed at creating and maintaining a motivational climate and organizational working conditions within the economic entity to ensure customer orientation and personnel loyalty. This approach enables employees to act not only as performers of tasks but also as active participants in implementing corporate philosophy, values, and strategies, thereby contributing to the achievement of organizational goals and the formation of a positive corporate image.

It is important to note that internal marketing is crucial not only for the service sector but also for economic entities in various industries (e.g., information technology), where the final product depends on the potential and motivation of personnel in the production process. At the same time, the quality of services and the satisfaction of external clients

directly depend on the satisfaction of internal consumers – the personnel. Therefore, it is pointless to promise an adequate level of service if the company's employees are not prepared to deliver it. Thus, internal marketing is based on elements of the traditional "4P" complex: 1) Product: The "work" offered to the employee includes the selection of appropriate personnel, effective internal training, proper distribution of powers and responsibilities, and the creation of conditions for teamwork. 2) Price: The benefits that employees receive from work (material and social) should exceed the alternative cost. 3) Place: The distribution is a set of spaces, processes, people, and decisions that form a platform for "economic entity-employee" relationships and ensure the reliability, openness, and transparency of these relationships. 4) Promotion: It manifests itself in the formation of corporate culture, the development of internal communications, PR activities, and the creation of a system of effective relationships between internal clients and suppliers, as well as external clients.

The main goal of internal marketing is to create favorable working conditions that ensure the high motivation, satisfaction, and loyalty of personnel. Its tasks include simultaneous orientation towards both clients and personnel, studying their needs, considering individual values and interests, reducing subdivisional isolation, developing a favorable microclimate, and overcoming personnel's resistance to innovation. Internal marketing is based on principles such as orientation to personnel needs satisfaction, motivation, cross-functional cooperation, readiness for change, and forming personnel and client loyalty. Its functions are grouped into five categories: 1) Analytical: Ensures the development of well-founded plans by studying the market and consumers. 2) Integrating: Unites personnel around common values and ensures mutually beneficial cooperation between subdivisions. 3) Information and Communication: Provides reliable and punctual information to all participants in the chain. 4) Stimulating: Activates personnel to achieve goals and satisfy their economic, social, and moral-emotional interests. 5) Managerial: Involves systematic influence on marketing activities through planning, organization, motivation, coordination, and control.

Further research should focus on evaluating the effectiveness of internal marketing in various economic sectors and developing performance indicators, considering adaptation to crisis conditions.

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ВНУТРІШНІЙ МАРКЕТИНГ ЯК ІНСТРУМЕНТ СТРАТЕГІЧНОГО РОЗВИТКУ ІННОВАЦІЙНОГО Й УПРАВЛІНСЬКОГО ПОТЕНЦІАЛУ І ЗМІЦНЕННЯ КОНКУРЕНТОСПРОМОЖНОСТІ СУБ'ЄКТІВ ГОСПОДАРЮВАННЯ

Вступ. Внутрішній маркетинг нині розглядають як комплексну систему партнерських відносин, що сприяє формуванню корпоративної культури, лояльності персоналу та клієнтоорієнтованості, що дає змогу підвищити задоволеність персоналу, зменшити опір змін, забезпечити синергію між підрозділами та досягнення стратегічних цілей суб'єкта господарювання. Актуальність теми зумовлена трансформацією економічних умов, підвищенням значення людського капіталу, необхідністю посилення внутрішньої взаємодії в межах організації.

Методи. Для узагальнення етапів еволюції внутрішнього маркетингу та формулювання авторського підходу до його визначення використано методи індукції і дедукції, комплексний підхід; для вивчення наукових підходів до трактування внутрішнього маркетингу, виявлення взаємозв'язків між елементами системи управління персоналом – методи аналізу і синтезу; для побудови концептуальної моделі внутрішнього маркетингу як інтегрованої системи взаємодії – методи абстрагування, логічного узагальнення та системний підхід. Інформаційну базу дослідження становили наукові праці зарубіжних і вітчизняних учених із питань маркетингу послуг, управління персоналом, організаційної поведінки та внутрішніх комунікацій, а також аналітичні матеріали й методичні джерела, що відображають сучасні підходи до реалізації внутрішнього маркетингу суб'єктів господарювання.

Результати. Обґрунтовано еволюцію підходів до визначення сутності внутрішнього маркетингу суб'єктів господарювання, його роль у формуванні ефективної системи управління персоналом і вплив на організаційну поведінку. Визначено, що сучасні трактування внутрішнього маркетингу охоплюють не лише діяльність із залучення, навчання та мотивації персоналу, а й побудову системи комунікацій, формування ціннісного простору, корпоративної філософії та культури для ефективного розвитку кадрового, інноваційного та управлінського потенціалу суб'єктів господарювання. Запропоновано авторське визначення внутрішнього маркетингу і запропоновано модель внутрішнього маркетингу суб'єкта господарювання з урахуванням виявлених ключових принципів, чинників та функцій, що базується на елементах класичної маркетингової моделі "4P", і містить елементи планування, комунікацій, контролю, репутаційної складової тощо.

Висновки. Проведене дослідження дозволило сформулювати авторське визначення внутрішнього маркетингу як інтегрованої системи партнерських відносин щодо управління людськими ресурсами, яка орієнтована на створення і підтримку мотиваційного клімату й організаційних умов праці всередині суб'єкта господарювання для забезпечення клієнтоорієнтованості та лояльності персоналу, де співробітники виступають не лише виконавцями функцій для підвищення якості обслуговування зовнішніх клієнтів і задоволення їхніх потреб і запитів, але й активними учасниками в реалізації корпоративної філософії, цінностей і стратегій для досягнення поставлених цілей і формування й підтримки позитивного іміджу суб'єкта господарювання. Запропоновано концептуальну модель внутрішнього маркетингу як механізм управління людськими ресурсами, який поєднує мотиваційні, комунікаційні, організаційні та культурні компоненти в межах суб'єкта господарювання.

Ключові слова: HR-маркетинг, управління людськими ресурсами, організаційна культура, залучення персоналу, споживач, стейкхолдер, якість обслуговування, партнерські відносини.

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MANAGERIAL AND FINANCIAL ASPECTS OF INNOVATIVE ACTIVITIES OF INTERNATIONAL COMPANIES: CASE ANALYSIS OF APPLE, GOOGLE, SAMSUNG, AND TESLA

Background. *The relevance of this study lies in the analysis of innovations as a key factor for competitiveness under globalization, the examination of modern approaches to organizing innovation activities, and the specific features of implementing innovation strategies in leading transnational corporations. The aim of the study is to offer both a theoretical foundation and a practical analysis of the specific aspects of innovation management in international companies. The object of the study is the processes of managing innovation activities in international companies, while the subject of the study comprises the approaches and tools used to manage innovations in transnational corporations and other international business entities.*

Methods. *To achieve the stated aim, general scientific and specialized methods were employed, including generalization and systematization, case studies, comparative analysis, and content analysis.*

Results. *Based on open analytical sources, an assessment of the level of innovation activity of Apple, Google, Samsung, and Tesla revealed both commonalities and distinctions in their innovation models.*

Conclusions. *The guidelines for enhancing innovation management systems in international companies have been substantiated, with particular focus on proposing methods to improve adaptability, openness to change, and the integration of digital technologies into innovation development processes.*

Keywords: *innovations, international company, AI, innovation model, efficiency, innovation management.*

Background

In today's context of globalization and digital transformation, innovation has become a key factor in the competitiveness of international companies. The rapid advancement of technology, shifting consumer demands, rising competition, and global market instability compel multinational corporations to introduce new products, processes, and business models continually. Innovation management is not just a tool for growth – it is a means of survival in an increasingly complex and ever-changing environment. At the same time, effective management of innovation activities requires consideration of numerous factors – cultural, organizational, economic, and legal – especially when operating across diverse markets. Given this, research on innovation management mechanisms in international companies is highly relevant. Analyzing the successful practices of leading global firms, identifying barriers, and developing efficient innovation strategies can form the basis for improving the performance not only of multinational corporations but also of national companies aspiring to enter global markets. Thus, exploring this topic holds both theoretical and practical significance for the modern economy.

The purpose of the research is to provide a theoretical foundation and practical analysis of the specific characteristics of innovation management in international companies, as well as to develop recommendations for enhancing the efficiency of innovation activities within the global business environment.

The object of the research is the processes of managing innovation activities within international companies.

The subject of the research includes the approaches and toolkits for innovation management in transnational corporations and other international business structures, as well as the factors influencing the effectiveness of innovation management in the context of globalization.

Literature review. Innovation, knowledge, and technology are key concepts in the field of international business (Aldeanueva, 2023). Cantwell (2017) highlights that innovation and internationalization processes are increasingly interconnected, becoming major drivers of development. Innovation is the cornerstone of growth and ensures organizations' resilience to market fluctuations. Business model innovations can serve as a pathway to competitive advantage, especially when the model is sufficiently differentiated and complex, making it difficult for existing and new players to replicate (Aldeanueva, 2023; Mishra, 2023; Mazur, Boguslavskyy, & Moroz, 2025). Emerging models of innovation development have encouraged many companies to change the way they source ideas, shifting towards open search strategies that involve a wide range of external contributors and sources (Kozlovskiy et al., 2025).

Innovation refers to the introduction of new or significantly improved products, services, processes, organizational methods, or marketing approaches that create added value or increase operational efficiency

(Pereira et al., 2022; Dluhopolskyi, Katola, & Dluhopolska, 2023). In other words, innovation represents novel practices with practical applications that bring benefits, be they economic, social, technological, or otherwise.

The main types of innovations are presented in Table 1, among which product, process, organizational, marketing, and social innovations can be distinguished.

In historical retrospect, the key innovation breakthroughs can be summarized in Table 2. This evolutionary chain illustrates how innovations, from mechanics to artificial intelligence, have transformed not only production but also social structures, the economy, and approaches to labor.

Table 1

Types and examples of innovations		
Type	Characteristic	Example
Product innovations	Creation or significant improvement of goods or services	A new smartphone with unique features
Process innovations	Changes in production technologies or service delivery methods	Warehouse automation using robots
Organizational innovations	New management methods, structures, or business models	Transition to a remote work model
Marketing innovations	Novel approaches to promotion, branding, or pricing	Use of neuromarketing in advertising campaigns
Social innovations	Solutions that improve the quality of life or address social issues	Platforms providing support for people with disabilities

Source: developed by the authors based on (Aldeanueva Fernández, 2023; Mishra, 2023; Potecea, & Cebuc, 2010; Vergeles, & Baiura, 2024).

Table 2

Historical progression of innovation from industry 1.0 to industry 5.0			
Industry era	Key innovations	Key changes	Effects
Industry 1.0 – Age of steam 1760–1840	Steam engine (James Watt)	Shift from manual labor to mechanized production; growth of textile, coal, and iron industries	Urbanization, expansion of the working class, new sales markets, poor working conditions, and pollution
Industry 2.0 – Rise of electricity and mass production 1870–1914	Electricity, internal combustion engine, assembly line (Henry Ford), telephone, radio	Creation of factories with conveyor production; development of transport and communications	Industrial growth, demand for skilled labor, emergence of labor unions
Industry 3.0 – Digital era 1960s–2000s	Computers, microprocessors, automation, CAD/CAM systems	Automated production, use of IT in manufacturing processes, and globalization of supply chains	Increased precision, reduced costs, and productivity growth
Industry 4.0 – Smart technologies 2010s–present	Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, IIoT	Smart factories, autonomous systems, telemedicine, driverless vehicles	Real-time monitoring, data-driven decision-making, and reduced downtime
Industry 5.0 – Human-centered manufacturing From 2020s onward	Human–robot collaboration, product personalization, ethical production, sustainability	Enhanced employee well-being, a balance between productivity and environmental responsibility	Fatigue sensors, resource reuse, flexible communication technologies (IO-Link Wireless)

Source: developed by the authors based on (Levi, 2024; Gander, 2023; OECD, 2023).

Many contemporary scholars (Cherep, & Markova, 2012; Polishchuk, 2009; Likhota, 2025; Yazlyuk, Butov, & Kostetskyi, 2012; Shestakovska et al., 2025; Syhyda et al., 2023) unanimously regard Joseph Schumpeter as the founder of innovation theory, referencing his seminal work "The Theory of Economic Development" (1912). This Austrian-American economist was the first to introduce the concept of "innovation" into scientific discourse, defining it as an independent, original, and essential component of the economic system. He also classified types of innovation and explored their impact on enterprises' production activities, laying the foundation for the emergence of innovation studies as an academic discipline. In the context of international business, Schumpeter's ideas evolve into a pressing need for constant renewal of products, processes, and business models in response to the dynamic changes of the global environment.

Under current conditions, the Open Innovation Model, proposed by Henry Chesbrough, has gained significant importance. This approach involves leveraging both internal and external ideas for the development of new products and solutions. International companies with access to global markets and networks actively engage startups, universities, research centers, and consumers in co-creating

innovations. Equally important is the Resource-Based View (RBV), which posits that a company's innovation capacity is determined by its internal resources and competencies. In the international context, this implies the effective utilization of intellectual capital, cross-cultural knowledge, technological platforms, and network connections.

There are numerous innovation models globally, classified according to various criteria, such as chronological stages, sources of origin, complexity level, and actors involved in the process (Severyna, Fyliuk, & Skopenko, 2024). These models emerge from the ongoing development of innovation theory and practice, reflecting technological progress, changing societal needs, and the evolution of economic systems. They serve both descriptive and analytical functions, helping to better understand the mechanisms of innovative activity in organizations, regions, and countries.

Among the earliest contributions to innovation theory were linear models, which describe the innovation process as a sequential flow from idea to market. In the technology push model, innovations are initiated by scientific discoveries, which subsequently advance through applied research, product development, and commercialization. In contrast, the market pull model suggests that innovations

are driven by consumer or market needs, prompting companies to seek solutions through research and development. Despite their simplicity, these approaches are often criticized for overlooking the complex interactions among various factors influencing the innovation process (Potecea, & Cebuc, 2010).

More complex and realistic models have emerged to replace linear approaches – among them, the chain-linked model, which emphasizes the presence of feedback loops between the stages of the innovation process, as well as the need to integrate knowledge from diverse sources such as the market, science, and production. This perspective allows for consideration of the unpredictability of innovations and the role of iterative refinement.

In today's innovation landscape, the open innovation model, based on the idea that organizations can no longer rely solely on internal resources and knowledge, has gained significant traction. Instead, they must actively engage external ideas, technologies, and partnerships (Polishchuk, 2009). This approach accelerates the innovation process, reduces development costs, and enhances organizational flexibility.

Another crucial theoretical framework is the systemic model of innovation, which views innovation as the result of interaction among multiple actors within an innovation ecosystem – universities, governments, businesses, financial institutions, and others. Depending on the scale of such interaction, one can distinguish national, regional, or sectoral innovation systems. This model places primary emphasis on the role of institutional environments and coordination among participants.

An extension of the systemic approach is the triple helix model, which emphasizes close interaction among three key spheres: universities (knowledge generators), business (sources of investment and commercialization), and government (regulator and policy actor). This collaboration creates conditions for synergy and the formation of new organizational forms of innovation activity (Cherep, & Markova, 2012; Polishchuk, 2009). In later adaptations, the model evolves into the quadruple helix (including civil society) and the quintuple helix, which adds an environmental dimension.

Modern innovation approaches increasingly adopt design thinking and user-driven innovation, placing the focus on a deep understanding of user needs, empathy, and iterative testing of solutions. This approach is especially prevalent in digital technologies, healthcare, and education sectors where rapid adaptability and product personalization are critical.

In contemporary fields such as education, healthcare, and information technology, diverse innovation models are actively applied. In education, for example, open innovation is implemented through collaboration with IT companies like Google and Microsoft to develop platforms such as Google Classroom and Moodle, enabling universities to deliver innovative content. The triple helix model envisions government funding of university research, later utilized by businesses to create educational products like adaptive learning tools. The systemic model of educational ecosystem development involves interaction among educational institutions, ministries, startups, and international foundations to foster innovation.

In healthcare, chain-linked models are used to develop medical technologies based on feedback loops among doctors, patients, and developers. Open innovation is also

actively applied by pharmaceutical companies that involve external researchers to create new drugs, as demonstrated during the COVID-19 pandemic. The design thinking model in healthcare focuses on developing patient-centered solutions, such as telemedicine interfaces or more user-friendly medical devices.

In the field of information technology, technology push, particularly the advancement of artificial intelligence and blockchain, drives the creation of new business models and products like ChatGPT and AWS. Open innovation is evident in open-source initiatives such as Linux, Mozilla, and TensorFlow. The systemic model in IT, especially in Silicon Valley, illustrates successful interaction among universities, venture funds, startups, and corporations in fostering innovation.

Methods

The research uses theoretical methods such as analysis, synthesis, generalization, and systematization to examine scientific approaches to innovation management. In addition, empirical methods are applied, including case studies, comparative analysis, and content analysis, to evaluate innovative practices in international companies.

Results

A defining feature of innovation-led development is its intensive nature. Within the context of innovation, the concept of "development" should be understood as economic growth based on qualitative internal transformations, driven by the integration of new knowledge into practice.

Figure 1 illustrates the relationship between innovations, represented by the Innovation Index (blue line), and global GDP growth rates (green line). As the figure shows, improvements in innovation levels correlate with an increase in GDP growth rates (% compared to the previous year), which supports the notion that innovation plays a key role as a driver of economic progress. The graph shows a positive correlation, as innovation increases over the years, GDP growth tends to increase as well. The alignment between peaks and valleys in both lines suggests a moderate to strong positive relationship. The coefficient of correlation is closer to +1, indicating that innovation and GDP growth rise together over time.

Across the globe, the highest levels of innovation activity are observed in research and development services, the pharmaceutical industry, specialized equipment manufacturing, and ICT service providers (OECD, 2023). Companies often implement multiple types of innovation simultaneously. Industries exhibit distinct innovation profiles, as firms in different sectors tend to focus more on either product innovation or business process improvement. Innovation indicators reveal that process innovations are more prevalent than product innovations (OECD, 2023). Canada demonstrates the highest proportion of companies (83%) implementing innovations during the period 2018–2020, followed by Israel at 74% (OECD, 2023). In all countries, the share of employment within innovative companies consistently exceeds the share of innovative enterprises among all businesses. On average, around 50% of companies introduced innovations between 2018–2020, whereas innovative firms accounted for 73% of total business-sector employment. This suggests that companies with higher employment levels tend to exhibit greater innovation propensity.

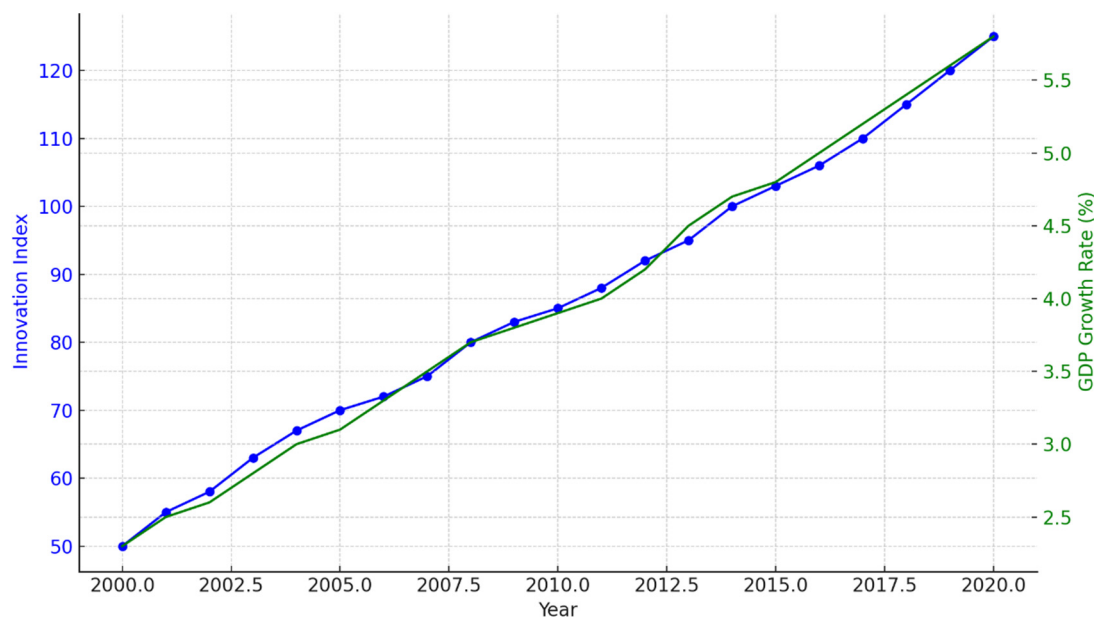


Fig. 1. Correlation between innovative growth and global GDP

Source: developed by the authors based on (WIPO, 2024; International Monetary Fund, 2024).

Innovation activity refers to the set of actions and processes aimed at the creation, implementation, and commercialization of new products, technologies, services, organizational or marketing solutions. It reflects the degree of companies' involvement in innovation and their capacity to renew products and processes to enhance competitiveness.

Key characteristics of innovation activity in international companies:

1. Development of new products and technologies, reflected in investments in research and development (R&D).
2. Implementation of innovations through the integration of new solutions into management activities.
3. Investments in innovation via funding for technical upgrades, equipment modernization, and acquisition of licenses and patents.
4. Collaboration with research institutions or other companies.
5. Protection of intellectual property through patenting new developments and technologies.
6. Innovation marketing – promoting new products to market.

We will analyze the innovation strategies and innovation activity of several international companies, leaders in innovation, including Apple, Google, Samsung, and Tesla.

The innovation activity of the international company Apple Inc. is one of the key characteristics that defines its global success, market strength, and reputation as a technological leader. In particular, the company is a leader in the following areas:

1. *Technological innovations in products.* Apple is renowned not only for creating new products but also for radically transforming the markets in which it operates. The most notable examples include:

- iPhone (2007): a revolution in mobile phones, combining a touchscreen interface, an intuitive user experience, and mobile internet access;
- iPad (2010): the creation of a new segment in consumer electronics – the tablet market;
- Apple Watch (2015): a major push into wearable technology, with a focus on health and fitness tracking;

- AirPods and AirPods Pro: wireless earbuds that have become a symbol of convenience, design excellence, and seamless integration within the Apple ecosystem;

- Apple Silicon (2020): a strategic shift from Intel processors to Apple's own M1/M2/M3 chips, delivering higher performance and energy efficiency across Mac devices.

- *Innovative business model and ecosystem.* Apple has developed a closed and interconnected ecosystem of devices, software, and services, which includes:

- integration of macOS, iOS, iPadOS, watchOS, and tvOS, ensuring a seamless user experience across all platforms;
- services such as iCloud, Apple Music, Apple Pay, Apple TV+, and the App Store, which provide a stable source of revenue and foster customer retention;
- control over the entire value creation chain, from design and hardware to software and customer service, enabling Apple to maintain high quality and brand consistency.

3. *Design and user experience (UX).* Apple is one of the pioneers in design, where interface and device form-factor innovations play a leading role. The company emphasizes simplicity, minimalism, ergonomics, and attention to detail. Continuous interface enhancements, such as Face ID, gesture-based navigation, and the Dynamic Island on iPhone, demonstrate Apple's commitment to intuitive user interaction. The Apple design language has had a significant influence on the entire industry, setting benchmarks for aesthetic and functional excellence.

4. *Innovations in privacy and security.* Apple actively advances innovative approaches to data protection, including: implementation of App Tracking Transparency (ATT); on-device user data processing; use of Secure Enclave, Touch ID, and Face ID.

5. *Investment in research and development (R&D).* Apple consistently increases its R&D spending: in 2023, expenditures exceeded \$30 billion, setting a record for the company. These investments support innovations in areas such as augmented reality (AR), artificial intelligence (AI), health technologies, and autonomous transportation.

6. *Development of artificial intelligence and AR/VR.* Apple is developing the Apple Vision Pro, a spatial computing headset that combines virtual and augmented

reality. The company is also integrating AI/ML into its products: Siri, automation in iOS, photo enhancement, and content personalization.

7. *Innovations in sustainability.* Apple is actively investing in environmentally sustainable solutions: using recycled materials in its devices, committing to becoming carbon neutral by 2030, developing carbon-free aluminum, and energy-efficient manufacturing processes

8. *Patent activity.* Apple is among the leading companies in terms of the number of patents filed each year: it files thousands of patents annually in areas such as hardware, UX, AR/VR, artificial intelligence, and more. The company actively protects its intellectual property, which reflects a strategic approach to innovation.

Analysis of Apple Inc.'s financial indicators over the last five years (Table 3) illustrates key trends in revenue, profit, margins, and other important financial metrics. In 2023, Apple recorded its first annual revenue decline since 2019,

dropping by 3%. However, in 2024, the company resumed growth, reaching \$391.04 billion in revenue. After peaking in 2022 at \$99.80 billion, Apple's net income decreased in 2023-2024, which may indicate market saturation and rising competition. Net profit margin remained stable, exceeding 25% from 2021 to 2023, but fell to 23.97% in 2024, potentially pointing to rising costs or reduced efficiency.

Although the iPhone remains Apple's primary source of revenue, the share of services (such as Apple Music, iCloud, App Store, etc.) continues to grow, providing more stable and profitable income streams. The company's spending on research and development rose from \$16.22 billion in 2019 to \$29.92 billion in 2023, underscoring its focus on innovation and emerging technologies. Despite the decline in net income in 2023-2024, Apple maintains high profitability and a strong balance sheet, allowing it to invest confidently in future growth.

Table 3

Key financial indicators of Apple Inc., in billions of dollars

Years	Revenue	Net Income	Gross Profit	Net Income Margin, %
2019	260.17	55.26	...	...
2020	274.52	57.41	104.96	20.91
2021	365.82	94.68	152.84	25.88
2022	394.33	99.80	170.78	25.31
2023	383.29	96.99	169.15	25.31
2024	391.04	93.74	180.68	23.97

Source: developed by authors based on (Macrotrends LLC, 2025; Bullfincher, 2025; Associated Press, 2023).

Apple's financial indicators over the past few years demonstrate stability and the ability to adapt to changing market conditions. Growth in revenue from services and investments in innovation positions the company for continued success, despite challenges such as smartphone market saturation and global economic fluctuations.

Apple manages its innovation through (Table 4): centralized leadership, vertical integration, large investments in R&D, strict process control, a strong focus on user experience, and high product quality. These factors enable

the company to maintain a sustainable competitive advantage and deliver breakthrough products that reshape markets.

Overall, Apple's innovation activity is not just about creating new devices. It's a systematic strategy that encompasses product innovation, design, services, privacy, sustainability, intellectual property, and user experience. It is precisely through ongoing innovation that Apple maintains its leading position in the tech world, setting the pace for the entire industry.

Table 4

Apple Inc.'s innovation management

Managerial aspects	Examples
1. Centralized management and visionary leadership	Strategic vision: innovative ideas are directed from the very top. Apple doesn't merely respond to the market – it creates it. Customer focus: the company invests in understanding user needs even before users themselves become aware of them.
2. Robust R&D (research and development) sector	Apple invests tens of billions of dollars annually in research and development, over \$29 billion in 2023. The company operates its R&D centers in the United States, Europe, Israel, India, and China. Apple aims to maintain control over critical technologies within the company, including chips (Apple Silicon), software, display technologies, and more.
3. Vertical integration	Apple controls nearly the entire product creation chain – from design and engineering to manufacturing and sales. This allows the company to implement innovations quickly, synchronously, and without compromising quality. For example, developing its processors enables deep integration of hardware and operating systems.
4. Closed management and innovation protection	Apple operates in a high-security environment. Teams often don't know what other departments are working on, which helps prevent leaks but complicates cross-functional collaboration. Innovation is protected by an aggressive patent strategy – Apple files thousands of patents every year.
5. Cross-functional teams	Apple structures its innovative activities not by products, but by functions (such as design, hardware, software, etc.). Teams from various departments (including engineers, designers, and marketers) collaborate closely to develop new solutions.
6. User feedback and data	Apple collects data from millions of devices, helping to identify trends, improve user experience (UX), and uncover new opportunities for innovation. The company actively implements machine learning to analyze user behavior and personalize products.
7. Focus on long-term innovation	Apple doesn't rush to implement "raw" technologies but introduces innovations only when they reach maturity and readiness for the mass market. For example, the development of the Vision headset took over 7 years.

Source: developed by authors.

Google, as one of the world's leading international technology companies, demonstrates strong innovation activity – a key factor behind its global success. Founded in 1998, the company quickly evolved from a search engine into a diversified tech giant that actively develops new products, services, and technologies across various fields.

The foundation of Google's innovation lies in substantial investments in R&D (research and development). Every year, the company pours billions of dollars into advancing

areas such as artificial intelligence, machine learning, cloud computing, quantum technologies, and autonomous systems. For example, through its development of AI, Google has created innovative products like Google Assistant, Google Translate, based on neural networks, and enhanced its search engine ranking algorithms.

The financial performance indicators of Alphabet Inc. (Google's parent company) for the period 2021–2024 are presented in Table 5.

Table 5

Key financial indicators of Alphabet Inc., billions of dollars

Years	Revenue	Net Income	R&D Expenses	Net Income Margin, %
2021	257.64	76.03	31.56	29.5
2022	282.84	59.97	39.50	21.2
2023	307.39	73.80	45.43	24.0
2024	350.02	100.12	49.33	28.6

Source: developed by authors based on (Alphabet Inc., 2024; Bullfincher, 2025).

Alphabet demonstrates steady revenue growth, with revenue reaching \$350.02 billion in 2024 – a 13.9% increase over 2023. Following a dip in 2022 to \$59.97 billion, net profit rose to \$73.80 billion in 2023 and \$100.12 billion in 2024, indicating effective cost management and improved profitability. Alphabet continuously increases its R&D spending, reaching \$49.33 billion in 2024, highlighting the company's focus on innovation and technological advancement.

Advertising remains Alphabet's primary source of revenue, accounting for approximately 87% of the company's total income through Google Ads and AdSense. In 2024, Google Cloud contributed 12% of the company's revenue, showing notable growth driven by the implementation of AI-powered solutions.

Google's innovation strategy is also built on the "20% time" philosophy, which allows employees to spend part of their working hours on personal projects. Notably, products like Gmail and Google News were created under this initiative.

Additionally, Google actively engages in mergers and acquisitions of startups with high innovation potential, enabling the company to stay at the forefront of technological advancement (Bullfincher, 2024).

Google X (now simply X) is responsible for implementing so-called "moonshot projects" – high-risk technological initiatives with potentially significant impact on the future. Among such projects are autonomous vehicles (Waymo), delivery drones (Wing), and internet-delivery balloons (Loon).

Google's innovation activity spans the globe – the company operates research centers in various countries, including the United States, the United Kingdom, Israel, India, and others. This approach allows Google to account for local market nuances and attract top talent from around the world. Therefore, Google's innovation efforts are systemic, large-scale, and strategically driven. The

company constantly seeks new ways to improve its technologies and expand its applications, allowing it to remain a leader in the digital technology space.

Samsung Electronics, part of the South Korean conglomerate Samsung Group, holds a leading global position in introducing innovations in electronics, telecommunications, information technology, and home appliances. Its innovation activity has been a key factor in long-term growth, global expansion, and competitiveness.

Samsung invests substantial resources in research and development (R&D). The company runs one of the largest private R&D programs in the world. In 2023, its R&D expenses exceeded \$21 billion, accounting for approximately 8-9% of its annual revenue. Samsung operates over 200 research centers globally, including in the United States, South Korea, Israel, India, and China. The company consistently ranks among the top three worldwide in terms of patent filings, having submitted over 10,000 international patent applications in a single year.

Table 6 presents the dynamics of Samsung Electronics' key financial indicators for the period 2020–2024. From 2020 to 2022, the company showed steady growth in revenue and profitability, from \$182 billion in 2020 to over \$232 billion in 2022. Net profit in 2022 reached \$42.1 billion, the highest figure during the period, driven by strong demand for semiconductors and electronics amid the pandemic. In 2023, profitability declined sharply – net profit dropped to \$11.13 billion, due to falling chip prices, reduced global demand for consumer electronics, and high inflation. In 2024, a recovery began: revenue rose to \$231.44 billion, and net profit increased to \$25.86 billion, indicating market stabilization, rising sales, and effective crisis management by the company.

Table 6

Key financial indicators of Samsung Electronics, billions of dollars

Years	Revenue	Net Income	Net Income Margin, %
2020	182.16	20.07	11.02
2021	215.08	30.18	14.04
2022	232.48	42.10	18.11
2023	199.18	11.13	5.59
2024	231.44	25.86	11.01

Source: developed by authors based on (Samsung Electronics, 2024; MarketScreener, 2025).

Overall, Samsung Electronics has demonstrated the ability to quickly adapt in conditions of market instability. After a downturn in 2023, the company successfully recovered its financial performance in 2024, indicating effective strategic management and strong innovation potential.

Examples of Samsung's innovative projects include:

1. Flexible displays – Samsung pioneered the commercialization of flexible OLED displays, which are used in its Galaxy Z Fold and Z Flip smartphone lines.

2. 5G Technologies – the company is one of the global leaders in developing and deploying 5G infrastructure, offering end-to-end solutions and partnering with major telecom operators worldwide.

3. Artificial intelligence and internet of things (IoT) – through its SmartThings platform, Samsung is actively expanding a smart device ecosystem that integrates appliances, sensors, and mobile devices into a unified experience.

4. Memory chips and processors – Samsung holds a leading position in the global semiconductor market and continues to develop its own Exynos chips for mobile and wearable devices.

Samsung's innovation strategy is based on an open innovation model, which involves cooperation with universities, startups, and research centers. To support its innovation development, the company has established several internal incubators and corporate venture funds – most notably Samsung NEXT, which invests in startups in IT, artificial intelligence, and data security.

Samsung's innovation management system includes: decentralized research governance through regional innovation hubs; internal incentive programs that promote employee-driven innovation; flexible organizational structures that enable rapid market introduction of new products; proprietary innovation evaluation standards, including regular reviews of patent portfolios, innovation efficiency indexes, and innovation profitability metrics.

Samsung integrates innovation into global supply chains, adapting products to local markets. Its innovations often have multi-sectoral impact, for example, display and battery technologies are used not only in smartphones but also in TVs, laptops, and even the automotive industry via Samsung SDI.

Tesla Inc., founded by Elon Musk in 2003, is one of the world's most innovative companies. Tesla has achieved breakthroughs in electric vehicles, battery systems, solar energy, and artificial intelligence. Innovation is not only a part of Tesla's products – it's the foundation of its business model, corporate culture, and competitive advantage.

Table 7 presents the dynamics of Tesla's key financial indicators for the period 2020-2024. From 2020 to 2022, Tesla experienced rapid growth in revenue and profit. Notably, net profit increased from \$0.72 billion in 2020 to \$12.56 billion in 2022, reflecting effective production scaling and rising demand for electric vehicles. In 2023, the company achieved a record net profit of \$15.00 billion on revenue of \$96.8 billion. The net profit margin remained stable at 15.5%, indicating efficient cost management and strong product demand. Despite a slight revenue increase to \$97.7 billion in 2024, net profit dropped significantly to \$7.13 billion, and the profit margin fell to 7.3%. Key reasons included declining average vehicle prices, increased competition in the EV market, and rising R&D expenses, especially in artificial intelligence and robotics.

Table 7

Key financial indicators of Tesla, billions of dollars

Years	Revenue	Net Income	Net Income Margin, %
2020	31.5	0.72	2.3
2021	53.8	5.52	10.3
2022	81.5	12.56	15.4
2023	96.8	15.00	15.5
2024	97.7	7.13	7.3

Source: developed by authors based on (Tesla, Inc., 2024; Electrive.com, 2025).

Tesla actively implements both technological and organizational innovations. Key areas of its innovation activity include:

- next-generation electric vehicles: Tesla was the first to bring fully electric cars to the mass market with long driving range, fast charging, and modern interfaces;
- autonomous driving: the company developed one of the most advanced autonomous driving algorithms – Tesla Autopilot and Full Self-Driving (FSD). Tesla uses neural networks and machine learning to continuously improve its software;
- innovative battery technology: Tesla has created proprietary battery packs with higher energy density, lower production cost, and improved environmental sustainability;

- integration of energy solutions: Tesla manufactures solar panels, Solar Roofs, and Powerwall home energy storage systems, forming a clean energy ecosystem that supports energy independence and grid resilience;

- Tesla Bot (Optimus) – a humanoid robot project that represents a breakthrough in artificial intelligence, robotics, and automation. Optimus is designed to perform repetitive or dangerous tasks and is being tested in Tesla factories.

Tesla uses unconventional approaches to innovation management that differ significantly from traditional corporations (Table 8).

Table 8

Tesla's innovation management

Managerial aspects	Examples
1. Vertical integration	Tesla controls nearly all stages of development, production, and distribution, allowing it to implement innovations quickly without delays from contractors
2. Intensive culture of experimentation	The company constantly tests new technologies without fear of failure. The "fail fast" culture encourages rapid product improvement
3. Centralized knowledge management	Tesla concentrates all engineering resources within internal teams, where software, design, and mechanics interact in a unified system
4. Leadership	Elon Musk is personally involved in shaping the company's innovation strategy, often initiating risky and ambitious projects. His influence fosters a culture of high expectations and deep technological engagement
5. Investment in R&D	In 2023, Tesla spent over \$3.97 billion on research and development (R&D), which accounted for approximately 5% of its annual revenue

Source: developed by authors.

Tesla's innovations are shaping new standards in the automotive, energy, and IT industries:

1) Tesla has become a catalyst for the energy transition to electric transport;

2) The company is establishing a new business model – "transportation as a service", based on autonomous driving and on-demand mobility;

3) Tesla promotes its technologies through open patent licensing, stimulating development across the entire industry.

Tesla Inc. is an example of a company that systematically manages innovation, transforming breakthrough technologies into commercial success. Its approach is grounded in risk-taking, rapid scaling, deep technological integration, and a strong vision for the future. Tesla doesn't just create new products – it is reshaping the very logic of development in global industries.

In today's globalized world, innovation has become a key factor in the competitiveness of international companies, with Apple, Google, Samsung, and Tesla serving as prime examples. Effective innovation management enables organizations to adapt to rapid market changes, implement new technologies, and meet consumer needs.

Discussion and conclusions

In modern international business, innovation, knowledge, and technology play a pivotal role as drivers of economic growth and competitiveness. Innovation activity encompasses a wide range of transformations – from products and processes to organizational and marketing solutions. The historical evolution of innovation, from Industry 1.0 to Industry 5.0, demonstrates the profound impact of technological breakthroughs on the social and economic structures of societies (Odrekhivskiy et al., 2025; Kozlovskiy et al., 2025). Today, innovation is shaped not only within companies but also through open approaches based on collaboration with external agents such as universities, startups, and government institutions.

The success of innovation activity depends on knowledge integration, effective interaction among participants in the innovation ecosystem, and adaptation to market needs. Industry-specific factors, such as higher innovation intensity in pharmaceuticals, ICT, and knowledge-intensive services, highlight the uneven development of innovation across sectors.

At the same time, rising R&D expenditures, particularly in IT and construction, demonstrate businesses' willingness to invest in the future, reinforcing the role of innovation as a foundation for long-term growth.

The development of international innovation companies highlights several breakthrough achievements:

1. Alphabet Inc. demonstrates sustained financial growth and effective resource management. Revenue increases, especially in advertising and cloud services, along with significant investments in research and development, have strengthened the company's position in the global market. The rise in net profit reflects the successful implementation of strategic initiatives and adaptation to changes in the technological landscape.

2. Samsung exhibits exceptionally high innovation activity, combining internal development, global knowledge management, open innovation, and technological integration. This strategy ensures leadership across various sectors and enables the company to respond swiftly to changes in the technological environment and market demands.

3. Tesla Inc. showed significant financial growth between 2020 and 2023, reaching peak profitability in 2023. However, in 2024, the company faced challenges that led to a decline in profit despite stable revenue. This underscores

the importance of adapting to market conditions and managing costs effectively to maintain financial stability amid rising competition.

Among the key directions for improving the innovation development of international companies today are the following: digital transformation – using technologies such as AI, big data, IoT, and cloud computing to automate processes, accelerate the innovation cycle, and increase flexibility; open innovation ecosystem – collaboration with external partners (startups, universities) to enrich sources of ideas and accelerate innovation; innovative corporate culture – creating an environment that supports creativity, tolerance for mistakes, and initiative; investment in human capital – continuous learning, development of digital and leadership skills, and the formation of multidisciplinary teams; global innovation coordination – combining centralized strategic management with local adaptation through global R&D networks; and innovation for sustainable development – integrating environmental, social, and governance (ESG) principles into business models to create long-term value.

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УПРАВЛІНСЬКІ ТА ФІНАНСОВІ АСПЕКТИ ІННОВАЦІЙНОЇ ДІЯЛЬНОСТІ МІЖНАРОДНИХ КОМПАНІЙ: АНАЛІЗ КЕЙСІВ APPLE, GOOGLE, SAMSUNG TA TESLA

Вступ. Актуальність дослідження полягає в аналізі інновацій із позицій ключового чинника конкурентоспроможності в умовах глобалізації, розгляді сучасних підходів до організації інноваційної діяльності, а також особливостей реалізації інноваційної стратегії в провідних транснаціональних корпораціях. Метою дослідження є теоретичне обґрунтування та практичний аналіз особливостей управління інноваціями в міжнародних компаніях. Об'єктом дослідження виступають процеси управління інноваційною діяльністю у міжнародних компаніях. Предметом дослідження є підходи й інструменти управління інноваціями в транснаціональних корпораціях та інших міжнародних бізнес-структурах.

Методи. Для досягнення поставленої мети використано загальнонаукові та спеціалізовані методи, зокрема, узагальнення та систематизація, кейс-стаді, порівняльний аналіз і контент-аналіз.

Результати. На основі відкритих аналітичних джерел здійснено оцінювання рівня інноваційної активності компаній Apple, Google, Samsung та Tesla, що дозволило виявити спільні риси та відмінності у їхніх інноваційних моделях.

Висновки. Обґрунтовано напрями вдосконалення системи управління інноваціями в міжнародних компаніях, зокрема запропоновано шляхи підвищення адаптивності, відкритості до змін та інтеграції цифрових технологій у процеси інноваційного розвитку.

Ключові слова: інновації, міжнародна компанія, ШІ, інноваційна модель, ефективність, управління інноваційною діяльністю.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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DYNAMIC OF ESG PERFORMANCE AND RISK-RETURN CORRESPONDENCE FOR LARGE US COMPANIES: EMPIRICAL ANALYSIS OF THE DJIA INDEX BASKET

Background. Legislative and regulatory changes are reshaping the landscape of Environmental, Social, and Governance (ESG) principles. This is prompting companies to reassess their commitments and implement new business development strategies that align with sustainable development. At the same time, certain "anti-ESG" trends, primarily in the US, are creating uncertainty regarding ESG performance dynamics, and the risk-return correspondence dynamics also appear unstable. These developments motivated the study's purpose: to examine the dynamics of ESG and risk-return correspondence from 2019 to 2024.

This paper presents results on the dynamics of 10 ESG subindexes and the K-ratio indicator for the largest US companies from 2019 to 2024. We also analyzed the hypothesis concerning the correspondence between ESG performance and the investment risk-return ratio.

Methods. Employed methods include factual and comparative analysis, statistical techniques, correlation estimation, risk-return measurement, synthesis, and deduction.

Results. We estimated the dynamics of subindices for 30 US companies from the Dow Jones Industrial Average (DJIA) index basket using statistical analysis of ESG scores. The subindexes exhibited convex upward trajectories, reaching their highest scores in the year when the COVID-19 pandemic began. Analyzing risk-return correspondence from 2019 to 2024 revealed persistent and significant changes in this ratio's value. A statistical analysis of the relationship between ESG scores and risk-return correspondence showed that there is no clear correlation between these two components. Therefore, it can be concluded that these two factors have distinct dynamics and that there is no clear relationship between ESG performance and market risk-return outcomes.

Conclusions. ESG principles are becoming an important component of sustainable business development; however, this process remains multifaceted and complex for large companies. The implementation of ESG scoring systems by several global rating agencies enables the identification and analysis of numerical patterns of this development. Current research focuses on analyzing the impact of ESG reporting on corporate financial and investment performance. Identifying such regularities will improve our understanding of the role and significance of ESG in the holistic analysis of corporate development.

Keywords: environmental, social, and governance reporting, ESG scoring, risk-return correspondence, K-ratio, correlation analysis.

Background

The concept of ESG has grown significantly over the last few decades. Although the term first appeared in a 2004 UN report, it did not gain widespread use until the late 2010s. The ESG concept is an integrated approach to managing a company's development that combines three key dimensions: Environmental (E), Social (S), and Governance (G). The environmental component includes measures such as greenhouse gas (GHG) emissions, resource use, pollution, and renewable energy. The social component reflects an organization's approach to diversity, equity, and inclusion concerning its workforce, human rights, equal opportunities, and other relevant aspects. The governance component focuses on corporate social responsibility (CSR) strategy, corporate governance structure, management, and shareholder relations. It can affect a company's long-term strategy and value (Mihail et al., 2021).

Incorporating ESG principles into corporate strategies has become important for companies seeking sustainable growth and competitive advantage. A key explanation is that

aligning corporate operations with ESG principles is expected to improve long-term financial and investment performance. In addition, companies are integrating ESG practices into their decision-making processes. This includes incorporating ESG indicators into performance evaluations to ensure that managers prioritize sustainability alongside traditional financial metrics. ESG practice in corporate strategy involves setting clear objectives, applying ESG indicators in decision-making, and fostering a culture that promotes sustainable development. It forms a holistic approach to elaborating company strategy and enables firms to create value for all stakeholders while addressing contemporary challenges.

The assessment of corporations' implementation of ESG principles is made possible through the analysis of ESG reporting and ESG scores produced by specialized providers. The ESG score is a comprehensive quantitative evaluation tool that numerically formalizes various parameters from different categories. It typically comprises several subindexes within individual evaluation categories,

while integral indices encompass the measurement of the E, S, and G constituents. Such numerical databases make it possible to evaluate the current state and dynamics of ESG implementation based on changes in subindices. On this basis, specific economic segments and industries can be assessed, which enables a better understanding of ESG levels across sectors through comparative analysis.

The present study employed a methodological approach grounded in the analysis of ESG subindex dynamics to evaluate a selection of large American companies that are constituents of the Dow Jones Industrial Average (DJIA) index. The relevance of such research is as follows. This methodological approach facilitates the identification of the impact of a nation's policy environment on the adoption of ESG principles. This is achieved by undertaking a comparative analysis of the dynamics of score values for the companies under study. The movement's relevance is further underscored by the escalating anti-ESG sentiment, which is garnering increasing momentum in various regions globally. This movement is predominantly centered in the United States and is expected to have ramifications for companies across various industries. The results of this trend were presented in the report *Strategic Intelligence: The Anti-ESG Movement* (GlobalData, 2025), which provides a comprehensive analysis of the US context in 2025.

The anti-ESG movement gained prominence in 2021 when the US state of Texas passed legislation prohibiting financial institutions from ostracizing companies involved in fossil fuel production. The predominant concern among financial institutions stemmed from the perceived inconsistency between ESG investing and their fiduciary obligations to act in the best financial interests of their clients.

In 2025, the efforts of the anti-ESG movement in the United States underwent a marked intensification. In that year, the US altered part of its previous policy on climate action and criticized the DEI (Diversity, Equity, and Inclusion) concept. The United States of America has also declared its intention to withdraw from the Paris Agreement, which was established in 2015. At the corporate level, several companies are part of this movement. At the same time, companies continue to incorporate a sustainability component into their development, provided it makes financial sense and investors look for similar alignment.

The situation in Europe differs from that in the US in that there is a persistent commitment to ESG investing. A survey conducted in January 2025 revealed that more than 90 percent of European investors expressed significant concern regarding the state of ESG practices and sustainable development in the United States. Concurrently, they maintain their intention to either maintain or increase their impact allocation. European investors generally have a positive stance on impact investing, despite concerns about developments in the US (Lewis, 2025).

These trends guided the research tasks, and the subsequent results are presented in this paper. The initial scientific undertaking entails the analysis of whether the observed trend in the USA was reflected in the ESG scores of prominent corporations, and if so, the manner in which such a reflection occurred. The second scientific task is to investigate the dynamics of investment risk in relation to risk-return correspondence. The third scientific task is to study the relationship between the dynamics of ESG index scores and the level of the investment ratio between risk and returns. These tasks provide the structure for achieving the overall research goal.

The structure of our paper is as follows. The Literature Review section provides an overview of publications that

present the results of analyzing the specified processes in the investment market. In the methodology section, we present our approaches to analyzing the three tasks previously mentioned. The findings of the research, accompanied by graphical representations, are delineated in the Results section. The final section presents the conclusions, which are based on the findings reported in the previous sections.

Literature review. Academic research, business practice, and corporate governance have dedicated significant attention to ESG performance, thereby establishing the implementation of these principles as integral to companies' sustainable development. This tendency is reflected in the rapid growth of publications on the topic. Al Azizah and Haron's (2025) bibliometric analysis of papers on ESG performance from 2013 to 2023 revealed a substantial annual publication growth rate of 26.81%. The ESG concept is an expansive one, encompassing a variety of economic and financial domains. Lykkesfeldt and Kjaergaard (2022) provide a comprehensive overview of the origins, history, and development of ESG in financial markets. They also consider ESG in the context of the total cost of doing business for a company, which is relevant when examining the dynamics of corporate ESG performance.

Passas (2024) delineates the evolution of ESG, thereby contributing to the elucidation of its conceptual and practical frameworks. The author presents a visual roadmap of ESG evolution with four stages. The initial stage (1950s–1990s) encompasses the emergence and evolution of CSR as a voluntary practice that addresses the ethical obligations of businesses. The second stage (2000s) is characterized by the emergence of ESG, with regulatory alignment and the standardization of selected metrics as its core components. The third stage, mainstream ESG (2010s), is characterized by the gradual integration of ESG principles into decision-making processes. The current stage, ESG 2.0 (2020s), is characterized by its integration into various strategies, the assessment of its results, and a pronounced focus on innovation. This roadmap facilitates a more profound comprehension of the dynamics of ESG as a factor of value creation and its role in business strategies.

The development of the ESG concept has occurred at disparate rates across nations and industries, and the methodologies employed in researching the role of ESG exhibit significant variation. Zatonatska et al. (2024) present a comprehensive analysis of best practices in applying ESG criteria within the energy sector. NABU (2024) expounds on the proactive integration of ESG principles by Ukrainian banking institutions. A salient related issue is the development of an ESG-oriented corporate culture. In particular, Prykazyuk, Pikus, and Lomonosova (2024) propose a concept for forming an ESG-oriented corporate culture in Ukrainian financial institutions. Consequently, when analyzing the dynamics of ESG, it is methodologically sound to consider the specific characteristics of each industry.

One of the actual questions of the ESG framework concerns the link between involvement in ESG activities and financial performance. Narula et al. (2025) presented a wide review of the current state of the literature on ESG investing and studied the impact of ESG ratings on firm performance. The authors attempted to collate scholarly work on ESG investing and considered questions about its impact on the firm. Research is groundbreaking because authors have considered this point from a diverse perspective.

In the present study, the ESG scoring toolkit was utilized, which is a numerical and multifaceted ESG score. There are numerous providers of this service. Darley (2025) delineates

the salient features of prominent ESG rating providers, including Fitch, Moody's, MSCI, EcoVadis, LSEG, ISS, CDP, S&P, and FTSE. The primary benefit of the scoring approach in our context is its capacity to provide a quantitative representation of ESG dynamics. This approach facilitates the identification of regularities in ESG dynamics and enables correlation analysis using numerical risk measures. In the course of our research, we employed tools provided by LSEG (formerly Refinitiv).

The utilization of ESG scoring is associated with considerable methodological intricacies from both economic and mathematical standpoints, which must be considered during the interpretation of results. Benuzzi et al. (2025) analyzed LSEG (Refinitiv) scoring values from 2012 to 2021, demonstrating that data aggregation and score normalization through percentile ratings significantly impact the representation of progress in sustainable development. In particular, the expansion of coverage to a greater number of companies has the effect of evaluating firms that have disclosed a limited amount of information. This can result in an artificial overestimation of the scores of the highest-rated companies. The authors propose replacing percentile scoring with a "performance ratio" methodology, contending that it produces more adequate scores and a more accurate reflection of sustainability performance for a given company.

Guerrero and Viteri's (2025) study examined the impact of specific indicators and categories on overall ESG scores, once again focusing on LSEG scores. The primary hypothesis posits that indicators measuring outcomes and impact possess limited influence on overall ESG scores, while indicators reflecting the implementation of activities, policies, or processes exert a greater influence. Their analysis indicates that among the 186 indicators that comprise LSEG ESG scores, outcome and impact indicators account for a mere 18–37% of the total, with the remaining contribution stemming from process and policy indicators. This suggests that companies can prioritize the reporting of information. Outcome and impact indicators are less susceptible to this issue because they assess tangible progress that is more difficult to manipulate.

The analysis of investment risk dynamics encompasses a wide range of approaches, and risk measurement can rely on both classic and advanced risk measures. Busu (2002) presents an overview of the evolution of investment risks and explores different modifications of their measurement and management. A fundamental element of this research is the analysis of mathematical tools for the evaluation of investment risk problems in real-world contexts. Kaminskyi, Butylo, and Nehrey (2021) have developed an integrated approach to risk assessment based on eight conceptual frameworks. These approaches consider risk estimation through volatility, losses in adverse situations, asymmetry, sensitivity, interdependency, and the coupling of risk and return. Furthermore, they assess risk evaluation within the framework of long-term memory in return time series and liquidity risk. Kaminskyi, Baiura, and Nehrey (2022) investigated the risk-return correspondence in an ESG investing strategy during the pandemic, comparing risk estimates before, during, and after the COVID-19 shock and revealing risk differences depending on ESG level.

The present study focuses on large US companies. The initial pertinent body of literature pertains to the correlation between ESG factors and financial performance. The following publication is hereby noted: Lunawat, Elmarzouky, and Shohaieb (2025) examined the impact of ESG factors on the financial performance of publicly traded US companies from 2013 to 2023. The researchers employed

data from 386 companies comprising the S&P 500 index, as well as over four thousand company-year observations. Regression models are employed to estimate the association between Environmental, Social, and Governance (ESG) scores and two financial indicators: return on assets (ROA) and Tobin's Q. The findings reveal a modest link with ROA but a relatively strong relationship with Tobin's Q, suggesting that ESG practices are connected to firms' long-term market value.

The second strand encompasses publications addressing attitudes toward ESG development and the frequency of changes in ESG-related policies and practices. Smetana (2021) delineates numerous state initiatives in the United States pertaining to ESG, observing that "US investors should be prepared for a considerably augmented focus and prioritization of ESG policies in the forthcoming months and years". Concurrently, Janknecht (2025) examines sustainability-related regulatory changes in the US in 2025, including the country's withdrawal from specific international agreements in this domain. The new administration rejected and denounced the Sustainable Development Goals and the UN's Agenda 2030, and a number of other anti-ESG measures were implemented. Media outlets such as Yahoo have characterized the United States as the "epicenter" of the mounting anti-ESG movement. This movement has also engendered opportunities by increasing demand for consulting services in this evolving landscape. A comprehensive review of the extant US literature reveals multidirectional trends in ESG that are subject to change over time.

Saci and Khalifa's (2025) review offers a comprehensive examination of research studies, reports, and articles from 2013 to 2024 concerning the evolving importance, trends, and developments of ESG in the European Union. Their analysis reveals discernible discrepancies between ESG development in the EU and in the US.

Methods

A variety of methodological approaches were implemented to address the formulated scientific tasks. The initial issue regards the selection of companies for analysis. Given the study's focus on the American market, a specific US stock index was selected, and the companies included in its index basket were used. The Dow Jones Industrial Average (DJIA) was selected as the index of interest. DJIA comprises 30 large industrial enterprises listed on the US stock exchange. A total of 30 companies have ESG estimation data available from 2019 onwards. While this set does not encompass the entire US market, it provides a consistent and analyzable sample for study. As an alternative, we considered the S&P 500 index, which includes the largest capitalized companies. However, aggregating ESG data for 500 companies over an adequately extensive historical period proved to be a formidable challenge, primarily because not all companies within the index possess long-term ESG scores. Therefore, for our study, the 30 DJIA companies constitute an acceptable sample for addressing the research tasks.

ESG scoring is a complex evaluation process that integrates a substantial volume of company information, particularly reported data, into numerical scores. A multitude of entities that provide ESG scoring services are currently operating within the market. Following an in-depth evaluation of the available products, LSEG ESG Scores were identified as the optimal solution. In our estimation, the assessments are meticulously designed to objectively and transparently evaluate a company's environmental, social, and governance (ESG) performance across ten

fundamental themes. These evaluations are grounded in publicly accessible, verifiable data, ensuring a high level of rigour and replicability. The structure of these ten topics, represented by ESG subindices, provided the core measurement toolkit for our research.

Consequently, an analysis of ESG scores was conducted, with the criteria delineated in the subsequent layout (Fig. 1).

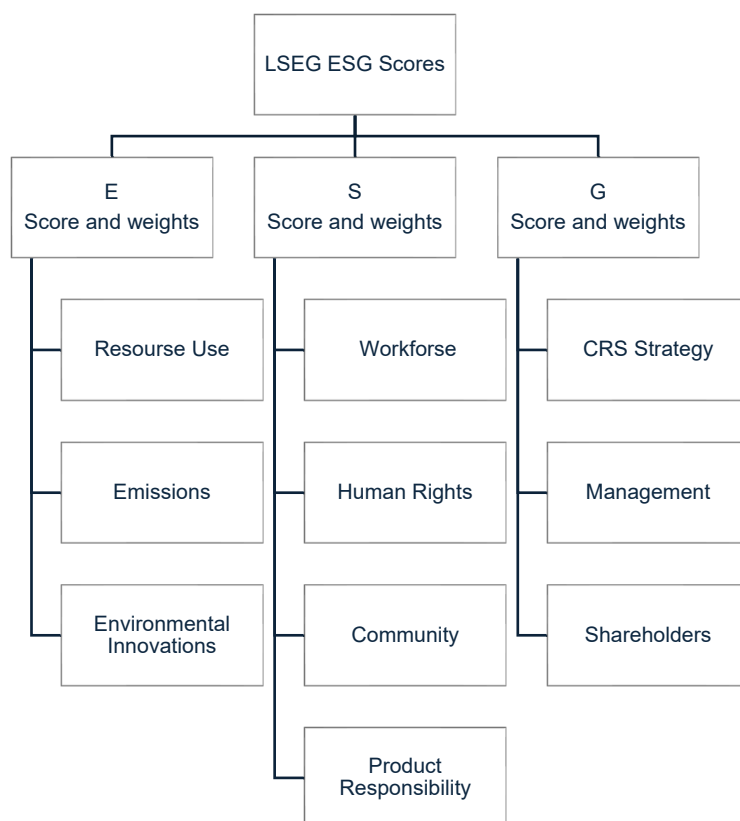


Fig. 1. LSEG ESG scoring system structure

Source: the scheme is formed on the basis [https://www.lseg.com/en/data-analytics/sustainable-finance/esg-scores].

The methodological approach to selecting time intervals involved using data from 2019 to 2023 for ESG dynamics (and up to 2024 for risk-return correspondence). The one-year step is indicative of the annual production of ESG scoring values by the provider, who utilizes annual reports in the process. When considering longer historical intervals, specific data challenges arise, including potential data gaps and changes or improvements in scoring methodologies. Concurrently, the designated time period is replete with informative content. In 2020, the COVID-19 pandemic significantly affected the activities of almost all companies, typically leading to a sharp drop in share prices, followed by a strong market recovery in the second half of 2020 and in 2021. In 2021, as previously mentioned, there was a notable increase in discourse surrounding the necessity of ESG strategies within the US market. During the 2022–2023 period, fluctuations in risk levels were evident. At the time of our study, the 2024 ESG scores had not yet been published; however, market price data were available to measure risk. Consequently, the time interval for ESG dynamics analysis was from 2019 to 2023, while for risk-return correspondence it was from 2019 to 2024.

To assess the dynamics of risk-return correspondence, a methodology was employed that integrated indicators of these two components into a unified metric. To this end, we employed the K-ratio logic to assess the correspondence. The K-ratio was first introduced by Lars Kestner in 1996 and subsequently modified (Kestner, 2013). It is a statistical

instrument that integrates the growth of returns and the consistency of that growth (the latter being interpreted as a risk indicator). Methodologically, it is suitable for our research because it is based on the logic of the Value-Added Monthly Index, which, in our case, was adapted from monthly to weekly intervals. K-ratios have been employed to evaluate the performance and long-term viability of equities, and they are regarded as a valuable complement to ESG scoring. To this end, we calculated K-ratios with a one-year time lag for the period 2019–2024.

The present study investigated the correlation between ESG in its quantitative representation and risk-return correspondence using correlation analysis. ESG performance is reflected in the values of 10 subindex metrics over 5 years, while companies' K-ratios were calculated for each year. A correlation analysis was conducted on the structured database, with the calculations performed independently for each year.

Results

The application of ESG scores necessitated the calculation of the mean values for the selected 30 companies. The mean values were computed for each of the ten ESG subindices. While individual companies exhibit different absolute scores, the averages capture general trends that are in line with our analytical approach. The primary outcomes are illustrated in Fig. 2. The overarching patterns are discernible, exhibiting a convex shape in the dynamics of nine out of ten subindices. The convex pattern

is absent only for the "CSR strategy" subindex (category G). One manifestation of this phenomenon is evident in the relatively pronounced increase in scores observed in 2020 compared to 2019. Specifically, the average increase across the three subindices in category E was 3.4 percent. The

mean increase for the four subindices in category S was 2.9 percent, and for the three subindices in category G, it was 4.7 percent. A notable observation is the substantial increase recorded by the "Shareholders" subindex, which exhibited a growth of 10 percent.

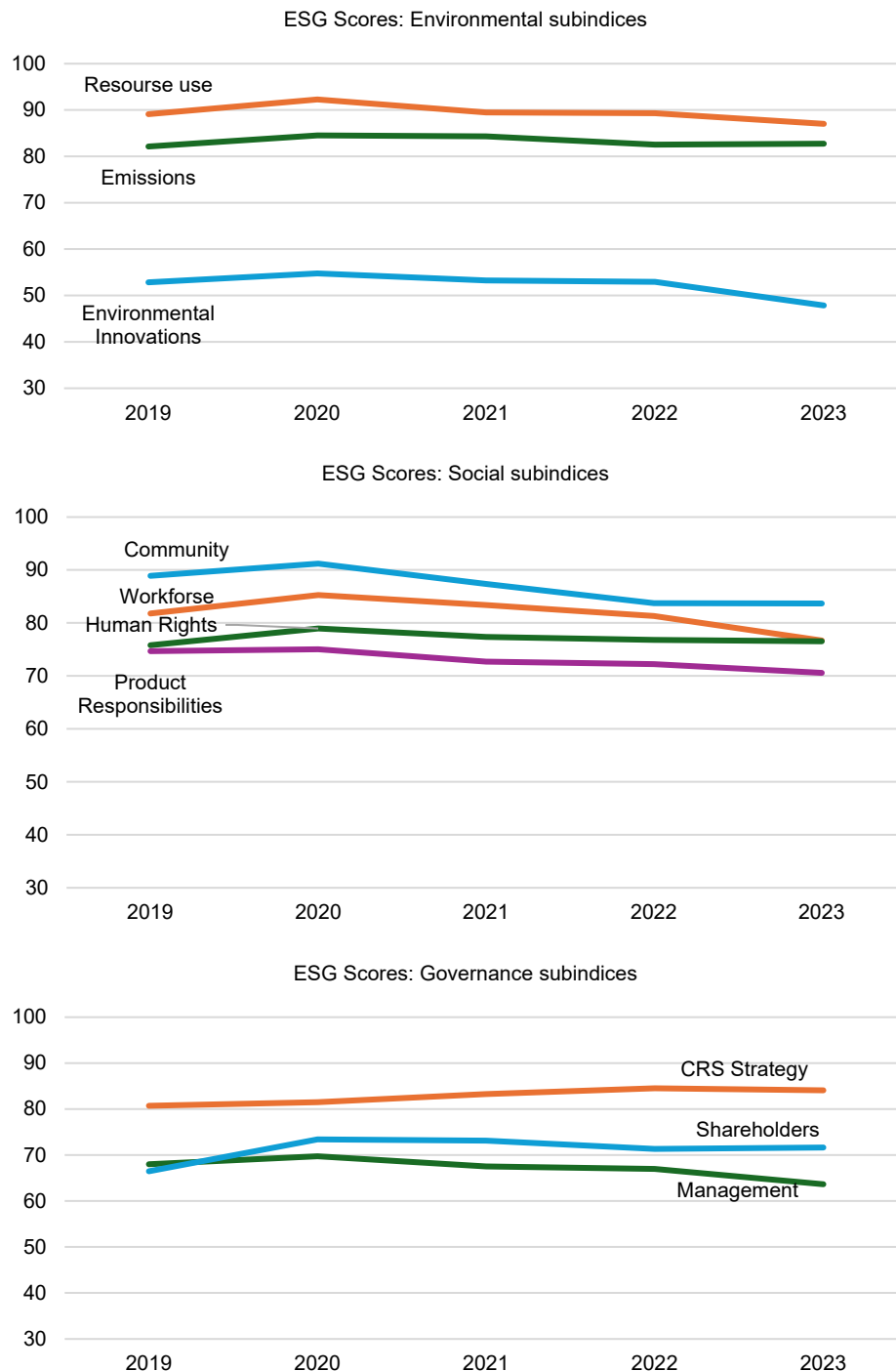


Fig. 2. Dynamics of sub-indices average scores for DJIA index basket companies

However, a shift in trend was observed in 2021. A decline in the mean values was observed. A comparison of the year 2021 with the year 2020 reveals a decrease of 2.0 percent for category E, 2.9 percent for category S, and 0.5 percent for category G. The only subindex that exhibited growth was "CSR strategy." A moderate decline was observed from 2021 to 2023.

A subsequent observation pertains to the disparity in absolute score levels across ESG categories. Within category E, the "Resource use" and "Emissions" subindices have relatively high values (above 80 points), while "Environmental innovation" is substantially lower (around 50 points). In comparison, the subindices within category S demonstrate greater homogeneity in both score levels and

dynamics. The behavior exhibited by the subindices in category G appears to be somewhat imbalanced. The term "CSR strategy" has exhibited a gradual upward trend, while the terms "shareholders" and "management" have been experiencing a steady decline since 2021. The discrepancy between "CSR strategy" and the other two G subindices exceeds 10 points.

The analysis of investment risk dynamics reveals high volatility in the risk-return correspondence. To this end, we used Value-Added Weekly Index (VAWI). The temporal framework was delineated on an annual basis to ensure

congruence with the annual frequency of ESG scores. As illustrated in Fig. 3, the VAWI volatility exhibited a fluctuating pattern throughout the study period. A comparison of the graphs indicates a marked increase in VAWI in 2019, 2021, and 2024+. In contrast, the high volatility in 2020 is associated with the COVID-19 pandemic. A pronounced decline is evident in 2022, while 2023 is marked by a predominantly horizontal trend. A comprehensive examination of VAWI from 2019 to mid-2025 reveals a substantial overall growth, amounting to nearly 100 percent over the aforementioned period.

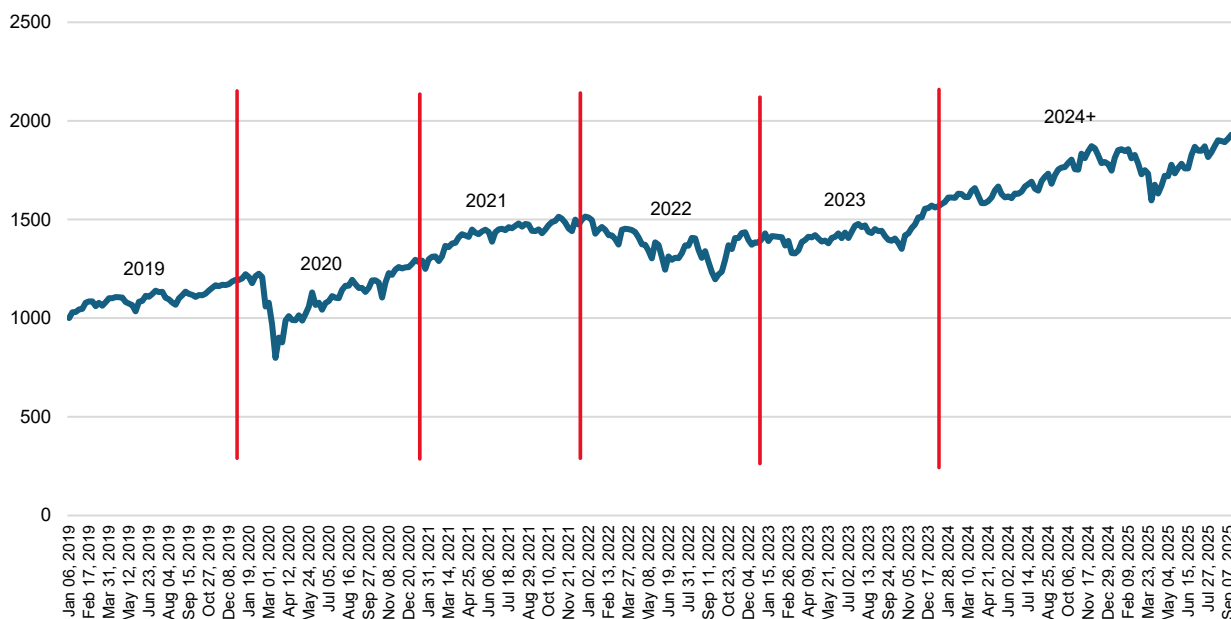


Fig. 3. VAWI for DJIA values. Annual division

A bar chart of the average K-ratio values and their standard deviations (STD), based on K-ratios for the 30 companies, is presented in Fig. 4. The findings of this study suggest a potential misalignment between the examined sample and the established mean ESG scores. Specifically,

K-ratios reach their zenith in 2019 and 2024, a phenomenon that contrasts with the convex pattern observed in the ESG scores. Consequently, K-ratio analysis can be utilized as an autonomous instrument to evaluate investments in index basket constituents.

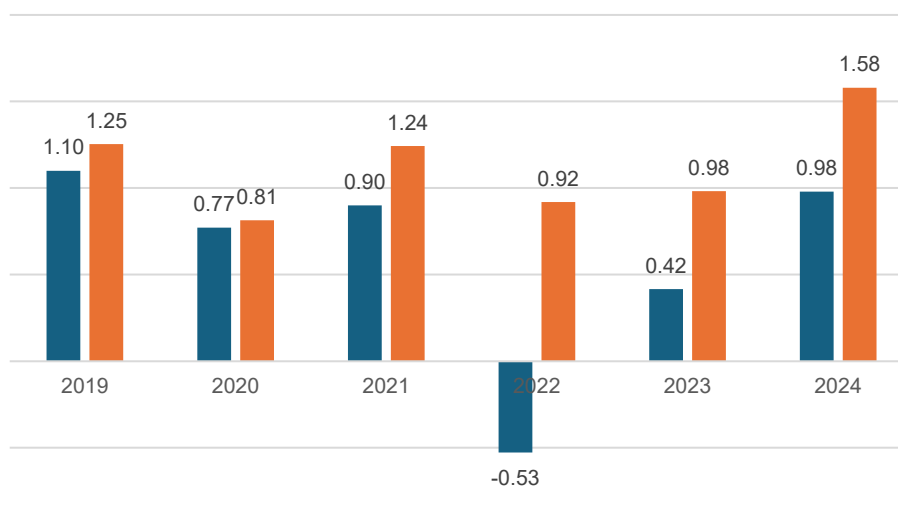


Fig. 4. K-ratios average (left columns) and STD (right columns)

The K-ratio is a quantitative measure of stock returns and VAWI dynamics over time; however, as illustrated in Fig. 4, its values exhibit considerable annual variation. The annual dynamics indicate a relatively high level of uncertainty. The K-ratio is a measure of stock performance, with higher values generally indicating higher investment efficiency. The persistent changes in K-ratio values over time reflect shifts in performance and provide a quantitative framework for characterizing this uncertainty.

The K-ratio was utilized to compare the returns and consistency of equities with different ESG scores. In the absence of observed dependence, a preliminary conclusion can be drawn regarding ESG scores: they appear to capture characteristics that are not directly related to market

movements. Conversely, the viability of an investment can be evaluated using the K-ratio.

The subsequent phase of the analysis involved examining K-ratio dynamics from a holistic perspective, that is, by considering the changes experienced by all companies collectively. In practice, the trajectories of K-ratio values differ across companies. This comprehensive approach was executed through the utilization of statistical analysis and radar charts over an extended period. The sequence of comparative graphs with one-year increments reveals substantial changes in K-ratios for the DJIA companies, as illustrated in Fig. 5. The overall dynamics of the system appear to follow an alternating sequence of improvements and deteriorations, suggesting a degree of uncertainty regarding its long-term performance.

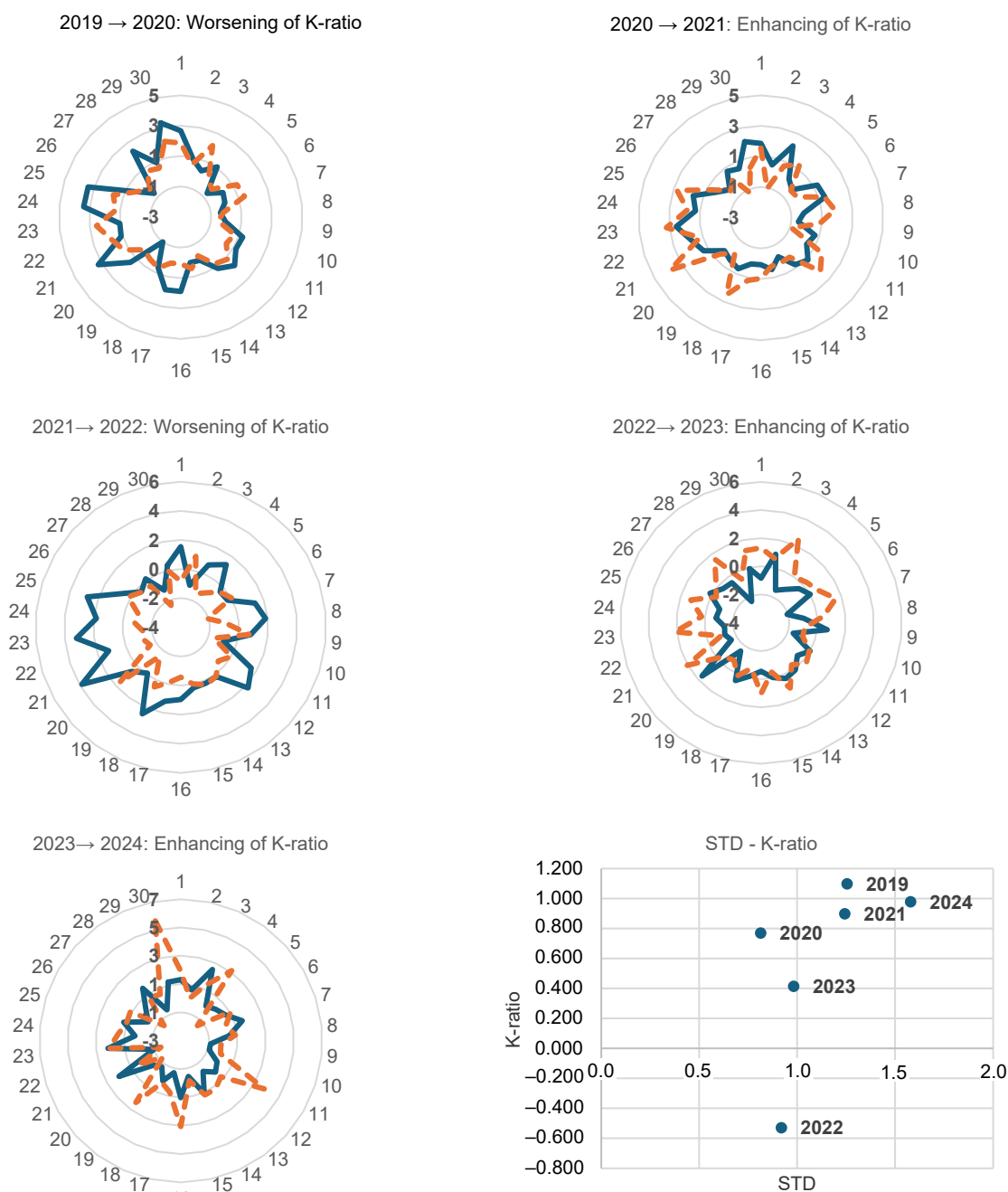


Fig. 5. Dynamic changes of the K-ratios at the company's level

Furthermore, the chart located in the lower right quadrant of Fig. 5 underscores the volatility of these dynamics and proposes a segmentation into two distinct groups. The initial cluster, designated as "2019, 2021, and 2024," manifests a relatively homogeneous nature, as evidenced by the application of the designated indicator. This cluster is distinguished by elevated levels of volatility and K-ratios. The second cluster, which includes 2020, 2022, and 2023, is distinguished by reduced volatility and notably divergent K-ratio levels. The findings of the second task can be encapsulated as such: the dynamics of investment risk, articulated through risk-return correspondence, manifest elevated uncertainty with persistent fluctuations in the direction of movement.

The third task was addressed using correlation analysis. Correlations were estimated between the 10 ESG subindices and the K-ratios. The analysis revealed no statistically significant correlation between ESG scores and risk-return correspondence. Furthermore, correlation coefficients were calculated for the aggregate ESG index and for the E, S, and G pillar scores. The correlation coefficients between these indices and the K-ratios were found to be nearly negligible. This finding suggests an absence of a detectable relationship between ESG dynamics (as reflected by scores) and the dynamics of risk-return correspondence.

Discussion and conclusions

The research findings enable us to draw several conclusions. The ESG concept is undergoing significant development in the USA, playing a pivotal role in the growth and evolution of major corporations. The dynamics of this development over the last five years were assessed using 10 LSEG ESG scores for companies included in the DJIA index basket. The analysis reveals a convex upward pattern in nine subindices (except for the "CSR strategy" subindex), with a peak in 2020. In summary, ESG scores increased in 2020, reached their highest point, and then began to decline. This phenomenon can be explained in two ways. First, companies' reactions to the pandemic, particularly the novel challenges it posed to their operations, can be cited as a primary factor. Second, the proactive support for ESG principles within US government policy during that period can be highlighted as a secondary factor. This support led to the implementation of ESG principles in corporate strategies, thereby influencing the market dynamics. Concurrently, the emergence of the anti-ESG trend in 2021 led to a moderation in the rate of ESG implementation and a decline in performance metrics.

The analysis further reveals nonuniformity in absolute score levels across different characteristics. Specifically, the category designated as "Environmental Innovation" (category E) exhibits comparatively diminished score values.

The investigation of risk-return correspondence was carried out using the K-ratio indicator. The findings indicate a dynamic pattern of change in companies' K-ratios. The average K-ratio over the past five years reflects a high level of uncertainty, with the average value turning negative in 2022. The proposed approach facilitates the tracking of the alternating nature of K-ratio dynamics, whereby periods of growth are succeeded by declines and vice versa.

The analysis of the correlation between ESG score dynamics and K-ratios indicates their mutual independence. The application of correlation analysis yielded coefficients that approximate zero, with deviations in most cases not exceeding 0.1. Consequently, no discernible relationship can be identified between these indicators. This finding indicates that the implementation of ESG does not appear to be

reflected in indicators of profitability or investment risk. In our view, the implementation of ESG strategies by companies is characterized by a certain degree of autonomy.

The findings indicate a pervasive degree of uncertainty, as evidenced by the variability in the K-ratio, in conjunction with a discernible pattern in ESG scores that is independent of the dynamics of risk-return correspondence throughout the study period.

Authors' contribution: Andrii Kaminskyi – conceptualization of the research, scientific guidance, preparation of the literature review and survey of theoretical foundations of the research, results analysis, formulation of conclusions, writing the original draft; Maryna Nehrey – development of research methodology, data analysis, writing at the context of critical review and editing; results visualization; Nuno Almeida – conceptualization of the research, development of research methodology, participation in the formation of analytical conclusions from the obtained research results; Ivan Shalenyk – collection and processing of empirical data, participation in the formation of analytical conclusions, visualization of data and technical editing of the text, design of the bibliography and preparation of the final version of the manuscript.

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ДИНАМІКА ЕФЕКТИВНОСТІ ESG ТА СПІВВІДНОШЕННЯ РИЗИК-ДОХОДНІСТЬ ДЛЯ ВЕЛИКИХ КОМПАНІЙ США: ЕМПІРИЧНИЙ АНАЛІЗ ІНДЕКСНОГО КОШИКА DJIA

Вступ. Законодавчі та нормативні зміни змінюють ландшафт екологічних, соціальних та управлінських принципів (ESG). Це спонукає компанії переглядати свої зобов'язання та впроваджувати нові стратегії розвитку бізнесу, які відповідають сталому розвитку. Водночас певні "анти-ESG" тенденції, насамперед у США, створюють невизначеність щодо динаміки ефективності ESG, і динаміка співвідношення "ризик-доходність" також виглядає нестабільною. Такий розвиток подій мотивує мету дослідження: вивчити динаміку ESG та співвідношення ризик-доходність з 2019 по 2024 рр.

Ця стаття має на меті представити результати щодо динаміки 10 субіндексів ESG та показника К-співвідношення для найбільших компаній США з 2019 по 2024 рр. Ми також проаналізували гіпотезу щодо відповідності між показниками ESG та співвідношеннями інвестиційного ризику та доходності.

Методи. Використані методи дослідження включали фактичний і порівняльний аналіз, статистичні методи, оцінювання кореляції, вимірювання ризику та доходності, синтез і дедукцію.

Результати. Ми оцінили динаміку субіндексів для 30 компаній США з індексного кошика Dow Jones Industrial Average (DJIA) за допомогою статистичного аналізу балів ESG. Субіндекси демонстрували опуклі догори висхідні траєкторії, які досягли найвищих значень у рік, коли почалася пандемія COVID-19. Аналіз співвідношення ризик-доходність з 2019 по 2024 рр. виявив постійні та значні зміни у значеннях цього співвідношення. Статистичний аналіз зв'язку між балами ESG і співвідношеннями ризику та доходності показав, що чіткої кореляції між цими двома компонентами немає. Отже, можна зробити висновок, що ці два фактори мають різну динаміку і що немає чіткого зв'язку між ефективністю ESG і результатами ринкового співвідношення між ризиком і доходністю.

Висновки. Принципи ESG стають важливою складовою сталого розвитку бізнесу; однак цей процес залишається багатограним і складним для великих компаній. Упровадження систем оцінювання ESG кількома глобальними рейтинговими агентствами дає змогу ідентифікувати й аналізувати числові закономірності цього розвитку. Поточні дослідження зосереджено на аналізі впливу звітності ESG на корпоративні фінансові й інвестиційні показники. Виявлення таких закономірностей покращить наше розуміння ролі та значення ESG у цілісному аналізі корпоративного розвитку.

Ключові слова: екологічна, соціальна й управлінська звітність, ESG-скоринг, співвідношення ризик-доходність, К-співвідношення, кореляційний аналіз.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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MIGRATION CHALLENGES AND GOVERNMENT POLICIES IN EU COUNTRIES AND UKRAINE AMID THE RUSSO-UKRAINIAN WAR

Background. This article is part of the project No. 101132435 – SKILLS4JUSTICE Topic: HORIZON-CL2-2023-TRANSFORMATIONS-01-03 and presents a comprehensive analysis of current migration processes in Ukraine and the multifaceted challenges they pose for the European Union. Since 2014, and especially following the full-scale Russian invasion in 2022, Ukraine has experienced one of the largest migration waves in Europe since World War II. The study highlights the socio-economic, educational, and political aspects of these migration flows, considering both internal displacement and international migration trends. The research examines the composition, motivations, and regional distribution of Ukrainian migrants in EU member states, emphasizing variations in labor migration, forced displacement, and student mobility. Special attention is given to the gender, age, and professional characteristics of migrants, as well as structural challenges they face, such as access to education, language barriers, labor market integration, and social inclusion.

Methods. The study employs a combination of statistical analysis, policy review, and thematic case studies across selected EU countries to provide an evidence-based perspective on migration dynamics and policy responses.

Results. The article examines the consequences of migration dynamics for the EU, including demographic pressures, labor shortages in certain sectors, strain on public services, and the need to adapt national and EU-wide migration policies. It analyzes how host countries address the integration of Ukrainian refugees and labor migrants, assessing the preparedness of education systems, labor markets, and social infrastructure to cope with a sustained influx. The paper evaluates the Ukrainian government's strategies for migration management and its cooperation frameworks with European institutions. It discusses potential long-term impacts of migration on Ukraine's human capital, including brain drain and the loss of skilled labor, alongside opportunities for circular migration and diaspora engagement.

Conclusions. Based on the findings, the article offers data-driven recommendations aimed at building more coherent, inclusive, and sustainable migration policies. These results are intended to support the formulation of informed policies in both Ukraine and the EU, within the broader context of regional stability, educational development, and socio-economic resilience.

Keywords: migration processes, ukrainian migrants, internal displacement, labor migration, integration policies, European Union, socio-economic impact.

Background

The Russian invasion of Ukraine in 2022 triggered one of the most significant forced migration crises in Europe since World War II. Millions of Ukrainians fled the country, while many others became internally displaced, leading to severe humanitarian, educational, and socio-economic challenges. These unprecedented migration flows have not only reshaped Ukraine's demographic landscape but have also had far-reaching implications for the European Union, particularly in the areas of labor markets, education systems, and migration governance. Despite the scale and impact of these displacements, there is still a lack of comprehensive and up-to-date academic analysis addressing both the internal and external dimensions of Ukrainian migration and their complex consequences for the EU.

At the same time, the rapid increase in migration poses long-term political challenges for both Ukraine and its

European partners. While EU countries have provided short-term support through temporary protection mechanisms, the sustainability of these measures remains uncertain. Issues such as brain drain, recognition of educational qualifications, labor market integration, and access to education for displaced children and youth require more strategic and coordinated responses. Therefore, understanding the current state and future trajectory of Ukrainian migration is essential for developing evidence-based migration policies that balance humanitarian needs with socio-economic integration and resilience across borders.

The relevance of this research is driven by the unprecedented scale of migration processes caused by the full-scale war in Ukraine, which has generated new challenges not only for Ukrainian society but also for the European Union. Millions of Ukrainians have become displaced—either abroad or within the country—significantly

affecting the socio-economic situation, labor markets, education systems, and migration policies in both Ukraine and the EU. In this context, there is a pressing need for a comprehensive analysis of current trends, risks, and opportunities related to migration in order to develop effective mechanisms for managing migration flows, ensuring migrant integration, and preserving human capital.

The **aim** of this study is to conduct a comprehensive analysis of the current state of migration processes in Ukraine and to identify the key challenges they pose for the European Union in the context of ensuring socio-economic stability, migrant integration, education policy development, and the formation of sustainable migration governance mechanisms during wartime and post-war periods.

Literature review. Human migration is an ancient social phenomenon that has accompanied humanity throughout its history. It has occurred for various reasons – from the search for better natural conditions and economic opportunities to escaping conflict, famine, or persecution. In the 21st century, the scale and nature of migration have changed significantly under the influence of contemporary armed conflicts. Wars in Syria, Afghanistan, the Balkans, and, since 2014, in Ukraine have become powerful drivers of forced displacement for millions of people.

Recent studies emphasize that, as of the end of 2023, the number of internally displaced persons (IDPs) worldwide reached a record high of 71.1 million, driven by armed conflicts, violence, and natural disasters. Among the main contributors to this increase are the war in Ukraine, along with other ongoing conflicts and environmental crises (IDMC, 2023).

The phenomenon of migration is analyzed globally, with particular focus on its causes, consequences, and policy challenges. Special attention is given to protracted displacement, the interconnections between climate change, armed conflicts, and urbanization, as well as the need for comprehensive approaches to protecting the rights and supporting the needs of internally displaced persons.

Given that such migration is a key component of global demographic and socio-economic dynamics, it has become the subject of numerous academic studies. In the context of this research, we focus on the analysis of studies specifically dedicated to migration processes in Ukraine and the associated challenges for the European Union.

A number of publications are devoted to general migration trends and the analysis of challenges faced by Ukrainian migrants. The current migration processes in Ukraine are analyzed, with particular attention to their evolution since 2014 and their escalation following the full-scale war in 2022. The main drivers of both internal and external migration are examined. The impact of migration on the labor market, social systems, and demographic dynamics is assessed. Special emphasis is placed on the need to develop an effective state migration policy in the context of the humanitarian crisis and Ukraine's integration into the European space (Kuryliuk, 2022). Numerous publications are devoted to internal migration, with particular focus on assessing the readiness of internally displaced persons for employment (Bilorus, & Firsova, 2023). The analysis focuses on how internal and external migration affect the forecasting of public education expenditures in Ukraine within the context of sustainable development. The methodology proposed by the authors enables the integration of migration trends into the planning of budgetary support for the education sector (Zatonatska et al., 2023). The impact of migration processes on forecasting Ukraine's healthcare budget expenditures is also explored in the

context of the Sustainable Development Goals. The authors develop a forecasting model that accounts for both internal and external migration, emphasizing the need to adapt budgetary policy to ongoing demographic changes (Zatonatska et al., 2022). Refugee flows from Ukraine to Poland and Germany in 2022 are analyzed with a focus on the specific characteristics of female migration, including the challenges faced by women migrants during integration and in accessing employment (Andrews et al., 2023). The socio-economic and labor-related challenges of Ukrainian refugees in Poland are assessed one year after the onset of the war, with particular emphasis on the underutilization of their qualifications and pathways to labor market participation (Berube, & Monras, 2023). The transnational mobility of Ukrainian women refugees is examined in the context of war and forced migration. The analysis focuses on how women adapt to new conditions in EU countries, engage with social institutions, and maintain connections with Ukraine through digital and emotional practices (Guild, & Groenendijk, 2023). The importance of developing long-term migration policies is emphasized both in Ukraine and in the EU member states (Pędziwiatr, & Magdziarz, 2023). The impact of the war in Ukraine on the mental health of displaced persons is examined. The authors analyse initial empirical data on levels of anxiety, depression, and post-traumatic stress among Ukrainian refugees, particularly women and children. The urgent need for systematic psychological support and the development of mental health programs for those who have experienced forced displacement is emphasized (Jurić, 2022). The ICMPD analytical report examines forced migration from Ukraine after 2022, with particular attention to refugee profiles, gender distribution, and levels of education. It highlights that Ukrainian migrants are generally highly educated but face significant challenges in labor market integration due to language barriers, legal restrictions, and uncertain prospects of return (Düvell, 2024).

A number of studies are devoted to analyzing the impact of migration from Ukraine on the socio-economic situation and labor markets of European countries. The social and economic effects of labor migration from Ukraine are examined, focusing on its impact on rural development, employment structure, and households. While migration provides significant remittances, it also contributes to demographic decline and growing social inequality in the regions of origin (Cantor, & Apollo, 2020). The participation of Ukrainian refugees in EU labor markets after the onset of the full-scale war is analyzed, with emphasis on both the speed of their employment and existing barriers, such as language difficulties, non-recognition of qualifications, and unstable legal status. The authors also provide policy recommendations aimed at enhancing the integration of Ukrainians into European economies and ensuring sustainable outcomes for both refugees and host societies. (Desiderio, & Hooper, 2023). The economic impact of the influx of Ukrainian refugees on EU countries is analyzed. The authors examine both short- and long-term effects, emphasizing that, with proper integration, Ukrainians can become a valuable resource for Europe's aging economies (Mykhnenko, Delahaye, & Mehdi, 2022). The forced migration from Ukraine following Russia's full-scale invasion in 2022 is also analyzed as an integral part of European security. The authors consider not only the humanitarian dimension, but also the political and strategic aspects of the crisis, emphasizing that the scale of population displacement has long-term implications for the EU, particularly in the areas of asylum policy, migration

governance, and regional stability (Maidanik, 2024). The Eurofound (2024) report examines the social impact of the influx of Ukrainian migrants into EU countries, focusing on the challenges related to their reception and integration (Fóti, 2024). The political, social, and legal aspects of refugee reception in the EU are analyzed, with particular attention to the implementation of the Temporary Protection Directive and the challenges of integration under conditions of uncertainty. Special focus is placed on how this crisis is reshaping European migration policy and raising new questions for the system of collective security and solidarity (Roskladka et al., 2022). Labor migration from Ukraine is examined as a component of contemporary mobility in Europe, with a focus on the political and economic factors shaping migration flows. The author analyzes how war, disparities in living standards, and labor demand in the EU drive both permanent and seasonal migration of Ukrainians. The study also explores the implications for labor markets, social policy, and the prospects for migrant integration in host countries (Pozniak, 2023). The response of EU countries to the mass forced migration from Ukraine following the outbreak of war in 2022 is analyzed. The authors examine the implementation of the Temporary Protection Directive, the divergences in member state policies, and the practical delivery of support to refugees. While the EU has demonstrated unprecedented solidarity, the lack of a coordinated approach and varying resource capacities has resulted in unequal conditions for the reception and integration of Ukrainians across different countries (Weisser, 2023). The EU's political response to the mass influx of Ukrainian refugees after 2022 is examined. The author analyzes how the war in Ukraine has reshaped the EU's approach to migration management. The report also highlights the need to revise the EU migration system in light of emerging geopolitical challenges and the solidarity demonstrated in response to the Ukrainian crisis. The long-term development of Ukrainian migration to Europe is examined, including political approaches, integration practices, and migrants' expectations. The authors analyze how changes in European migration policy affect Ukrainians and emphasize the need to develop sustainable strategies that balance the economic benefits for host countries with the social needs of the migrants themselves (Leontiyeva, 2014).

Numerous publications analyze the impact of Ukrainian migrants on the economies of specific countries and regions. The impact of the war in Ukraine on demographic trends and migration processes in the region is analyzed, with a focus on shifts in population structure, economic consequences, and challenges for neighboring countries. The author examines how the armed conflict has triggered mass displacement, particularly of women and children, leading to imbalances in the age and gender structure both in Ukraine and in EU countries. The article also highlights the need for a comprehensive international approach to migration management in the context of a humanitarian crisis (Dumitrescu, & Constantin, 2023). It is emphasized that the Ukrainian presence in Poland is not only a source of labor but also an important part of the country's social and demographic landscape (Levytska, 2022).

The education of migrants from Ukraine is examined, with particular attention to Ukrainian students as a distinct group of migrants affected by the war and forced to continue their studies abroad. The author analyzes the challenges they face within the education systems of EU countries and emphasizes the importance of supporting academic mobility (Libanova, & Pozniak, 2023). The impact of digital technologies on access to education for Ukrainians

displaced by the war is examined, with a focus on the use of remote learning as a tool for adaptation in times of crisis. The authors emphasize that digital education has become a vital means of sustaining the educational process, reducing learning losses, and preserving social connections among displaced individuals (Lapshyna, 2025).

An important aspect of the research is migration statistics. The UNHCR page contains up-to-date data on the situation of Ukrainian refugees and internally displaced persons following Russia's full-scale invasion of Ukraine (UNHCR, 2025). The Migration Data Portal provides key statistical data on mobility within and from Ukraine during 2020–2023, covering internal displacement, international migration, and returns. The report highlights a sharp increase in displacement following the start of the full-scale war, identifies major migration routes, outlines the demographic profile of migrants, and emphasizes the policy challenges arising in the context of the humanitarian crisis (IOM Global Data Institute, 2023). An important UNHCR publication explains how statistics on displaced persons are collected and used, including data on refugees, asylum seekers, and internally displaced persons. It clarifies the distinction between "stock data" (the number of individuals at a specific point in time) and "flow data" (the number of new displacements over a given period), and emphasizes the importance of accurate data collection for effective humanitarian response and policy development (UNHCR, 2025).

Summary publications on Ukrainian migration processes highlight several key findings by researchers:

First, the scale and multidimensional nature of Ukrainian migration. Nearly all authors note that the war in 2022 triggered the largest migration crisis in Europe since World War II. Migration flows are mixed in character, including labor, forced, student, family, and transit migration. Researchers also emphasize that Ukrainian migration is not only a challenge but also a potential resource for reshaping EU policy.

Second, the changing profile of migrants. Post-2022 external migration is characterized by a predominance of women with children, young people, students, and individuals with higher education. A significant share of migrants are highly qualified professionals, yet they often face challenges in realizing their potential due to barriers such as diploma recognition, language difficulties, and childcare responsibilities.

Third, the socio-economic impact. For Ukraine, migration results in labor shortages, the risk of human capital loss, demographic aging, reduced domestic demand, and growing regional disparities. Nevertheless, remittances from abroad remain a crucial stabilizing factor for the Ukrainian economy. For the EU, the response has been swift but largely temporary, with an uneven distribution of responsibilities across countries, especially Poland, Germany, and the Czech Republic.

Fourth, institutional adaptation. The EU activated the Temporary Protection Directive for the first time, demonstrating solidarity, yet the lack of coordination among member states undermines the effectiveness of long-term integration. Since 2014, Ukraine has also been developing an institutional framework for responding to migration, but it remains fragmented and poorly oriented toward long-term planning.

Fifth, access to education for Ukrainian migrants in the EU. Most Ukrainian children who fled to EU countries gained access to school education, though the adaptation process has been uneven, affected by language barriers, differences in education systems, and psychological trauma. In countries like Poland, the Czech Republic, and Germany, special adaptation classes were introduced, but children

often experience social isolation and struggle to fully integrate into regular schooling. Some students continued their studies in Ukrainian online schools from abroad, which ensured continuity but also created a "dual educational space" with limited integration into host systems.

Many students were forced to interrupt their studies or transfer to foreign universities. EU countries, including Poland, Germany, and Lithuania, offered scholarships, adaptation programs, and language support. However, some students faced insufficient recognition of completed coursework, a lack of housing assistance, and the need to restart their studies from the beginning. EU universities implemented the "Erasmus+ for Ukraine" program, which helped maintain academic mobility, although on a limited scale.

Internally displaced persons (IDPs) within Ukraine faced interrupted access to education due to relocation, overcrowding in schools in host communities, lack of housing, or inadequate technical support for online learning. Educational institutions often lacked the resources needed to integrate new students, particularly in rural areas or frontline regions.

The importance of digitalization in education is strongly emphasized as a key adaptation tool. In the context of displacement, online learning became a critical means of ensuring educational continuity and maintaining ties with Ukraine. At the same time, the digital divide, limited access to devices and the internet, and fatigue with remote learning posed additional challenges.

Nonetheless, long-term risks for education are highlighted. War and mass displacement have exacerbated educational inequality among Ukrainian children and youth. There is a growing risk of losing the country's educational potential, a decline in qualification levels, and a disruption of learning trajectories – particularly among vulnerable groups such as children from rural areas, IDPs, and children with disabilities.

Sixth, the psychological and humanitarian consequences. Many researchers underscore high levels of trauma, depression, and PTSD among displaced individuals, especially women and children. The need for long-term mental health support programs and integration through education, culture, and employment is emphasized.

Overall, the studies conclude that migration from Ukraine between 2014 and 2025 is not a temporary phenomenon but a long-term structural process that requires a new paradigm of migration policy. This involves both the strategic modernization of Ukraine's approach and a shift within the EU toward systematic migrant integration management—moving beyond crisis-driven responses. These insights underline the relevance, importance, and timeliness of our research project "Analysis of Migration Processes in Ukraine: Challenges for the EU."

Methods

The methodological foundation of this study combined analytical, statistical, and sociological approaches to reflect the complexity and dynamism of migration processes in Ukraine during wartime, as well as their impact on the European Union. The research employed the following methods: comprehensive analysis (including SWOT analysis, meta-analysis of academic literature, and review of national and international migration reports); statistical analysis (comparative, descriptive, and time-series analysis using data from the State Statistics Service of Ukraine, Eurostat, UNHCR, IOM, and other institutions).

Due to the extreme socio-economic transformations triggered by the full-scale invasion in 2022, the analysis distinguished between two key periods: the pre-war period (2014–2021) and the wartime period (2022–2024). This

distinction enabled the identification of both long-term trends and the immediate consequences of forced and voluntary migration. To assess labor migration and migrant qualifications, a sectoral analysis was conducted using updated employment and education indicators, with a focus on shortages and surpluses in key sectors such as healthcare, construction, IT, and logistics.

The study also incorporated scenario analysis to evaluate potential migration trends under different post-war recovery and EU integration scenarios.

Overall, the methodology captured the complexity of migration under crisis conditions and provided a data-driven foundation for developing policy recommendations aimed at improving migration governance, access to education, and labor market integration in both Ukraine and the European Union.

Results

The period from 2014 to 2025 has been a turning point for Ukraine's migration landscape. Internal migration intensified after 2014, but its scale increased exponentially in 2022–2023. In 2014, the annexation of Crimea and the armed conflict in Donbas, followed by Russia's full-scale invasion in 2022, triggered unprecedented levels of both internal and external migration. Internally displaced persons (IDPs) and refugees abroad have become a new social reality for millions of Ukrainians.

According to data from the State Statistics Service of Ukraine, the country experienced a positive migration balance before 2022 (see Fig. 1).

Between 2014 and 2021, Ukraine experienced a large wave of internal displacement, driven by the annexation of Crimea and the armed conflict in the eastern regions of the country (see Table 1).

The first significant surge occurred in 2014–2015, when the number of internally displaced persons (IDPs) in Ukraine rose to 1.6–1.8 million. This was the period of active military conflict in Donbas, during which hundreds of thousands of people were forced to flee the conflict zone and seek refuge in other regions of Ukraine. In 2016–2017, IDP numbers remained consistently high—approximately 1.6–1.7 million, with many living in temporary or inadequate conditions, often without prospects of return.

From 2018 onward, there was a gradual decline in the number of registered IDPs, associated both with the partial integration of displaced persons into new host communities and the diminishing relevance of formal registration due to complex or bureaucratic procedures. Between 2019 and 2021, the number of officially registered IDPs ranged from 1.4 to 1.5 million. The COVID-19 pandemic in 2020 also influenced population mobility and access to social services, potentially reducing the rate of registration updates.

Overall, during 2014–2021, a stable community of internally displaced persons emerged in Ukraine, requiring long-term solutions, particularly regarding housing, employment, access to education, and integration into host communities. Although the situation was not on the scale seen after 2022, this period laid the institutional groundwork, by both the state and international partners for response mechanisms that would later become critical during the full-scale war.

According to the study, the number of IDPs after 2022 reached between 6 and 8 million. The primary regions of displacement included Kyiv, Lviv, Dnipro, Kryvyi Rih, and western Ukraine. This placed significant strain on infrastructure, the labor market, the education system, and healthcare services. The government responded with initiatives providing housing subsidies, employment support, retraining, and integration assistance.

External migration expanded even further. Over 6–7 million Ukrainians fled abroad, primarily to EU countries, the United Kingdom, and Canada. The majority were women with children, resulting in the feminization of migration. These migrants actively entered host country labor markets, particularly in care work, services, healthcare, and education. At the same time, they encountered barriers such

as non-recognition of qualifications, difficulties with employment, and challenges in language integration. EU countries implemented programs for temporary protection, employment support, and adaptation to new conditions; however, the long-term financial sustainability of these programs remains uncertain (see Table 2).

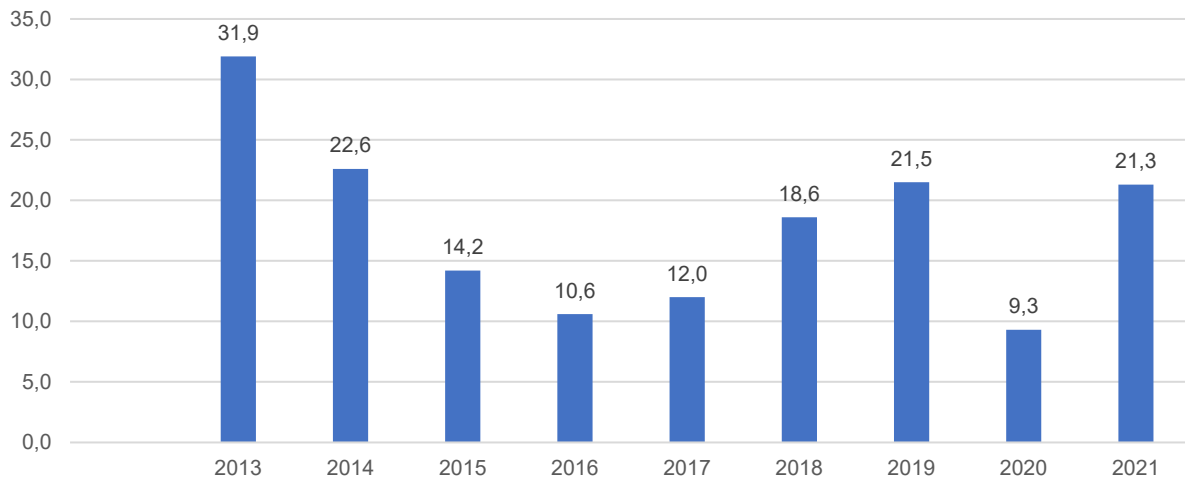


Fig. 1. Population migration between Ukraine and other countries: increase/decrease in population (thousands)
Source: compiled by the authors.

Table 1

Dynamics of the number of Internally Displaced Persons (IDPs) in Ukraine (2014–2021)

Years	Approximate number of IDPs (in millions)	Commentary
2014	0.9–1.2 million	Following the annexation of Crimea and the outbreak of hostilities in Donbas
2015	1.6–1.8 million	Peak registration of IDPs during the active phase of armed conflict
2016	~1.7 million	Stabilization of the situation; official registration continues
2017	~1.6 million	Some IDPs remain displaced but no longer update their registration
2018	~1.5 million	Minimal changes; the majority reside in government-controlled regions
2019	~1.5 million	Gradual trend toward integration or secondary migration
2020	~1.4–1.5 million	COVID-19 affected mobility and social assistance programs
2021	~1.4 million	Before the full-scale invasion, moderate decline in registered IDPs

Source: compiled by the authors.

Table 2

Estimated Volumes of Migration from Ukraine (2022–2025)

Type of Migration	Estimated number of Persons	Main Regions / Destination Countries
Internally Displaced Persons (IDPs)	6–8 million	Kyiv, Lviv, Dnipro, Kryvyi Rih
External Migration (Refugees)	6.8–7.5 million	Poland, Germany, the Czech Republic, Italy, Spain
Ukrainians under Temporary Protection in the EU	~4.7 million	EU countries (according to UNHCR, 2023–2024)

Source: compiled by the authors.

Table 2 illustrates the significant scale and diversity of migration from Ukraine between 2022 and 2025. It shows that an estimated 6 to 8 million people became internally displaced, primarily relocating to major urban centers such as Kyiv, Lviv, Dnipro, and Kryvyi Rih. At the same time, approximately 6.8 to 7.5 million Ukrainians sought refuge abroad, with the largest numbers settling in Poland, Germany, the Czech Republic, Italy, and Spain. Among them, around 4.7 million individuals were granted temporary protection status in EU countries, according to UNHCR data. These figures highlight the unprecedented nature of displacement and the pressing need for coordinated responses in both national and international migration policy.

Migration also had a reverse dimension: between 2023 and 2025, a gradual return of some refugees was recorded. According to surveys, 71% of Ukrainians consider returning

after the end of the war, with key conditions being safety, access to housing, and economic prospects. However, some migrants have already adapted to life abroad, particularly children who have integrated into educational systems, which complicates the return process (Operational Data Portal, 2025).

Quantitative indicators by country are presented in Table 3. According to data from the Statista portal, as of February 2025, more than 6.5 million Ukrainian refugees had been registered across Europe, confirming the enduring scale of the humanitarian crisis triggered by Russia's full-scale invasion of Ukraine. The majority of refugees have been received by countries in Central and Western Europe, some of which have provided long-term residence, integration programs, and temporary protection for hundreds of thousands of individuals.

Table 3

Number of Registered Ukrainian Refugees in Europe as of February 2025	
Country	Number of Refugees
Germany	1 243 445
Poland	993 795
Czech Republic	389 830
United Kingdom	253 535
Spain	216 975
Romania	177 715
Italy	171 545
Moldova	135 860
Slovakia	132 120
Netherlands	121 645
Ireland	112 680
Belgium	87 365
Austria	85 710
Norway	78 850
Bulgaria	75 260
Finland	69 345
Switzerland	68 000
Portugal	65 245
France	63 865
Hungary	61 470
Lithuania	48 085
Latvia	47 655
Denmark	39 810
Estonia	37 415
Turkey	34 510
Greece	33 105
Georgia	28 640
Croatia	27 560
Sweden	26 800
Montenegro	21 245
North Macedonia	19 325
Cyprus	18 740
Slovenia	12 915
Serbia and Kosovo	10 730
Albania	6 465
Azerbaijan	4 645
Iceland	4 005
Luxembourg	3 875
Malta	2 640
Liechtenstein	705
Armenia	605
Bosnia and Herzegovina	265

Source: <https://www.statista.com/>

The leading host country is Germany, which has accepted 1,243,445 refugees-nearly 20% of all registered Ukrainian refugees in Europe-becoming a key destination due to its developed infrastructure, strong social protections, and robust integration initiatives. Poland, with 993,795 registered refugees, has traditionally served as the primary entry route for Ukrainians, although a significant share of migrants subsequently relocates to other EU countries. The Czech Republic (389,830), the United Kingdom (253,535), and Spain (216,975) also rank among the countries with the most active refugee support policies. Together, these five countries have received over 3 million Ukrainian refugees, accounting for more than half of the total number.

In terms of employment, the number of Ukrainian refugees who have found work in Germany has increased significantly. In September 2024 alone, 8,500 Ukrainians gained employment-more than double the figure from September 2023. This was made possible through the "Job Turbo" initiative aimed at accelerating the labor market integration of refugees. By July 2024, 266,000 working-age Ukrainians were employed in Germany.

From a regional perspective, Central and Eastern Europe-comprising countries such as Poland, the Czech

Republic, Slovakia, Romania, and Hungary, served as the first line of humanitarian response, owing to their geographic proximity to Ukraine. Western European countries (Germany, France, Belgium, the Netherlands, Italy, and Spain) provided more sustained long-term support, including housing, healthcare, and employment opportunities. Northern Europe (Sweden, Norway, Finland, Denmark, Iceland) and the Baltic States (Lithuania, Latvia, Estonia) also participated in refugee reception efforts, albeit on a smaller scale.

An analysis of relative figures highlights the considerable burden placed on smaller countries. Although the absolute number of refugees in countries such as Moldova (135,860), Slovakia (132,120), or Lithuania (48,085) may be lower, the impact on national resources is relatively high due to their smaller populations and limited capacity. Notably, Moldova and Slovakia rank among the most burdened host countries in terms of the number of refugees per 1,000 inhabitants (Kostina, & Prots, 2024).

Ukrainian refugees have also influenced the socio-economic dynamics of these host countries. In Lithuania alone, over the first seven months of 2024, Ukrainian workers contributed €65.2 million in taxes – an increase of

€13 million, or 25%, compared to the same period the previous year. Since the start of the full-scale war, Ukrainian refugees working in Lithuania have paid a total of €205 million in taxes: €45 million in 2022, €95 million in 2023, and €65.2 million in the first part of 2024. According to official data, as of September 1, 33,900 Ukrainians were employed in Lithuania under labor contracts. The Employment Service currently offers them nearly 2,000 job vacancies. Most are employed in the transport and logistics sector (8,900), manufacturing (7,200), construction (6,700), and the hospitality and food service industries (3,000). Nearly 3,000, or 8.4%, work in high-skilled positions, while approximately 6,100, or 18.1%, are employed in low-skilled or unskilled jobs (Enovosty, 2024).

According to a study by the International Organization for Migration (IOM), nearly 60% of Ukrainian refugees residing in Moldova were able to find employment in 2024. Of these, 44% secured permanent jobs, 10% were hired as temporary workers, and 4% worked remotely or received passive income. However, there are notable gender disparities: only 35% of women found employment compared to 82% of men. The main barriers to employment included a lack of available opportunities (60%), language barriers (49%), and insufficient access to job market information (Ukrainska Pravda, 2024).

Some countries have hosted the fewest Ukrainian refugees. Fewer than 10,000 refugees have been registered in states such as Serbia and Kosovo (10,730), Albania (6,465), Iceland (4,005), Liechtenstein (705), Armenia (605), and Bosnia and Herzegovina (265). This is attributed both to geographic distance and to these countries' limited involvement in broader European migration policy frameworks.

Overall, the data reflect not only the level of solidarity shown by EU member states and Ukraine's neighbors, but also the uneven distribution of the refugee burden. Amid the prolonged conflict, stable Ukrainian diasporas are forming, integrating into host societies while maintaining ties to their homeland. These trends highlight the need for a long-term strategic approach to integration, employment, education, and the potential return of part of the displaced population to Ukraine in the future.

The study demonstrates that the migration crisis triggered by the war in Ukraine has far-reaching consequences for both Ukraine and the European Union. For Ukraine, it has become one of the most significant demographic and social challenges: between 2022 and 2025 alone, the country lost approximately 6.7 million people, with major effects on the population structure, labor market, and the capacity of social systems. Large-scale external migration, combined with internal displacement of more than 6 to 8 million people, has led to infrastructure overload in certain regions and increased regional disparities in access to education, healthcare, and housing (Duszczek et al., 2023).

For the European Union, this situation has become a catalyst for rethinking migration policy. Despite the successful activation of temporary protection mechanisms, member states have faced uneven burdens, along with challenges related to social integration, language adaptation, and ensuring access to basic services. Border countries such as Poland, Slovakia, and Moldova have borne the greatest pressure, with particularly high ratios of refugees to local population size.

Thus, for both Ukraine and the EU, the Ukrainian migration crisis has become not only a humanitarian emergency but also a structural event requiring a systemic, long-term, and coordinated approach. Ukraine must develop

return and reintegration policies, while the EU must transition from emergency responses to stable integration frameworks. Only under such conditions can migration flows be transformed from a challenge into an opportunity for recovery and cooperation.

In the same time, highly supportive EU policies and measures of integration of the Ukrainian refugees and significant success of this integration evoked some criticism and claims of the 'racism' of the EU refugees' policies, which are much more restrictive in relation to the other groups of refugees starting from the Syrian refugee crisis in 2015, or in case of flows of refugees from the African countries to the Southern EU countries via Mediterranean routes (Agier, 2025). Such claims are overly focused on the relevant racial and cultural proximity aspect in acceptance of refugees, but then the ignore or downplay other factors such as geographical proximity between the countries of origin and destination, abruptness and scale of the disruption causing the refugees crisis (Russo-Ukrainian war as the biggest continental war since the WW2), as well a relative smoothness of the integration process due to the previous experience of employment of the Ukrainian migrant workers, especially in Poland, Baltic countries and Romania.

This study has shown that the migration landscape of Ukraine between 2014 and 2025 underwent profound transformations, driven primarily by war, political instability, and socio-economic change. The combined effect of internal displacement and external migration created unprecedented demographic and political challenges for both Ukraine and the wider European region. The findings confirm that forced displacement is not merely a humanitarian issue but a long-term structural factor that necessitates a fundamental rethinking of migration governance at both national and international levels.

Internal migration – especially the mass displacement within Ukraine after 2022 – has placed enormous pressure on local infrastructure, public services, and labor markets in host regions. Despite state efforts to provide temporary housing, social assistance, and employment support, the integration of internally displaced persons (IDPs) remains uneven. Sustainable reintegration strategies, including the digitalization of services and regional development, are crucial for stabilizing internal mobility and preventing the marginalization of displaced communities.

On the other hand, external migration continues to affect Ukraine's labor force and human capital potential. While many Ukrainian migrants have found employment and social protection in EU countries under temporary protection schemes, the long-term demographic consequences for Ukraine are substantial. If migration becomes permanent for large segments of the population – particularly highly educated youth and women – the country risks irreversible losses in its innovative capacity, workforce productivity, and regional development.

Return migration presents both a unique opportunity and a significant challenge. A considerable number of displaced Ukrainians express a willingness to return, but this depends on post-war reconstruction, security guarantees, and trust in public institutions. Repatriation policy must be closely linked to broader plans for economic recovery, housing strategies, and reskilling programs that meet the needs of both returnees and local communities.

In conclusion, the current migration crisis requires a comprehensive and forward-looking approach that combines humanitarian aid with long-term development and policy planning. Ukraine must not only address the immediate consequences of displacement but also

formulate inclusive policies that strengthen resilience, protect vulnerable groups, and leverage the potential of its diaspora. Likewise, EU countries must move from temporary aid to structural support, recognizing that the integration of Ukrainian migrants is both a moral obligation and a strategic imperative for regional stability and shared prosperity.

Discussion and conclusions

The findings of this study confirm that migration processes in Ukraine between 2014 and 2025 have been largely shaped by protracted armed conflict and geopolitical instability. The annexation of Crimea and the war in eastern Ukraine triggered the initial waves of internal displacement, but the full-scale invasion in 2022 sharply intensified both internal and external migration. This resulted in the largest forced displacement crisis in modern European history, deeply impacting Ukraine's demographic structure and labor market. Internal displacement placed significant pressure on urban infrastructure, while external migration led to labor shortages in critical sectors of the economy.

The research reveals a mismatch between existing migration policy frameworks and the evolving realities of large-scale displacement. While Ukrainian authorities have made progress in coordinating humanitarian assistance, political instruments for managing return migration, supporting displaced professionals, and addressing long-term social integration remain underdeveloped. There is a pressing need to revise migration strategies with a forward-looking perspective, taking into account both national reconstruction goals and regional cooperation with EU partners.

Despite these results, several key issues remain open for deeper investigation. One such issue is the potential for the return of Ukrainian refugees after the active phase of the war ends. Although surveys indicate a high level of intent to return, actual migrant behavior may differ significantly—especially where partial integration abroad has already occurred. The long-term impact of human capital loss on Ukraine's economy, particularly in sectors already experiencing labor shortages, also remains an unresolved concern.

Future research should focus on evaluating the effectiveness of integration policies across different EU countries, particularly with attention to regional and social disparities. A promising direction is the comparison of refugee support models in both large and small host states, as well as the assessment of how these programs influence social cohesion in receiving communities. In addition, the experiences of Ukrainian children and youth within EU educational systems warrant deeper analysis—especially in terms of psychological adjustment, learning loss, and future employment prospects.

Moreover, the role of the Ukrainian diaspora in the country's postwar recovery should be studied further, along with the potential for building transnational social, educational, and economic networks. Central to upcoming policy discussions should be the design of return strategies that are not merely declarative but grounded in real support mechanisms – including access to housing, employment, education, and healthcare in the war-affected regions of Ukraine. Between 2014 and 2025, Ukraine's migration landscape underwent a profound transformation—from a relatively localized conflict in the east to a full-scale humanitarian crisis that affected the entire country and had cross-border implications. This led to large-scale demographic losses, a reduction in the labor force, shifts in the educational structure of the population, and significant pressure on social protection systems.

For Ukraine, the key challenges included the loss of a portion of the active population, particularly in sectors such

as healthcare, education, IT, and industry; overburdened infrastructure in regions hosting internally displaced persons (IDPs); and the urgent need for reintegration policies, including housing, reskilling, and support for small businesses. The Ukrainian state needs to recognize that not all citizens will return – and that mechanisms for circular mobility and engagement with the diaspora must be developed now.

For EU countries, Ukrainian refugees have helped fill labor shortages, particularly in sectors experiencing chronic workforce deficits such as logistics, care services, and agriculture. However, this has also increased pressure on housing, education, and healthcare systems – especially in Poland, Moldova, the Czech Republic, and the Baltic states. Successful examples of adaptation programs underscore the importance of long-term solutions rather than temporary responses.

Based on the conducted analysis, the following recommendations are proposed to improve migration policy and support the socio-economic reintegration of displaced persons:

Recommendations for Ukraine:

- Develop a national reintegration strategy for returnees and internally displaced persons (IDPs), which should include housing support, access to education, psychological assistance, and employment facilitation.
- Invest in infrastructure development and public services in regions that have received a significant number of IDPs, to prevent the overloading of local resources and promote balanced regional development.
- Strengthen employment and professional adaptation programs aimed at aligning migrants' skills with current labor market needs. For returnees, provide opportunities for retraining, entrepreneurship development, and the recognition of informal and foreign-acquired qualifications.
- Expand the use of digital public services and distance learning platforms, which have proven effective in conditions of displacement. This will help maintain access to education, professional development, and public services in mobile and crisis environments.
- Engage the Ukrainian diaspora and migrant communities abroad in the national recovery process by creating mechanisms for their participation in investment, innovation, and knowledge transfer.
- Ensure the collection of statistical data and the continuous monitoring and analysis of migration processes, disaggregated by age, gender, region, and status, to develop flexible and adaptive crisis response policies.
- Promote the development of an inclusive and non-discriminatory public discourse on migration to support social cohesion and prevent tension between host communities and displaced persons.

Recommendations for EU countries:

- Transition from short-term humanitarian solutions to long-term integration strategies. Temporary protection should gradually evolve into a systemic policy with clear mechanisms for access to education, the labor market, healthcare, and permanent residence.
- Facilitate the recognition of Ukrainian diplomas and qualifications by accelerating nostrification procedures, expanding retraining programs, and supporting the professional adaptation of migrants in sectors facing labor shortages (especially healthcare, education, care services, and IT).

Strengthen intergovernmental coordination with Ukraine to share migrant data, plan return policies, and involve Ukrainian

migrants in post-war recovery processes through joint educational, economic, and investment programs.

- Ensure adequate funding and support for local communities hosting significant numbers of Ukrainians by providing access to EU funds and creating targeted instruments at the municipal level.
- Incorporate a gender perspective into migration policy, particularly supporting mothers with children by improving access to childcare, schools, and flexible employment opportunities for women.
- Facilitate efforts in labor market integration and training of the refugees with special needs (disabled) by improving and expanding existing integration schemes and mechanisms.
- Develop voluntary and phased return mechanisms aimed at those who have expressed a desire to return to Ukraine, taking into account security, housing, and professional conditions for dignified reintegration.
- Support social dialogue and reduce xenophobic sentiments by informing the public about Ukrainians' contributions to host country economies, promoting cultural exchange, and encouraging civil society participation in integration policies.
- Modernize migration data collection systems to improve monitoring of the dynamics, needs, and profiles of Ukrainian migrants for effective policymaking.

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МІГРАЦІЙНІ ВИКЛИКИ ТА ДЕРЖАВНА ПОЛІТИКА В КРАЇНАХ ЄС ТА УКРАЇНІ В УМОВАХ РОСІЙСЬКО-УКРАЇНСЬКОЇ ВІЙНИ

Вступ. Ця стаття є частиною проєкту № 101132435 – SKILLS4JUSTICE HORIZON-CL2-2023-TRANSFORMATIONS-01-03 та представляє комплексний аналіз поточних міграційних процесів в Україні та багатограних викликів, які вони створюють для Європейського Союзу. З 2014 р., і особливо після повномасштабного російського вторгнення 2022 р., Україна пережила одну з найбільших міграційних хвиль у Європі із часів Другої світової війни. Дослідження висвітлює соціально-економічні, освітні та політичні аспекти цих міграційних потоків, враховуючи як внутрішні переміщення, так і тенденції міжнародної міграції. У дослідженні розглянуто структуру, мотивацію та регіональний розподіл українських мігрантів у державах-членах ЄС, з акцентом на відмінностях у трудовій міграції, вимушеному переміщенні та мобільності студентів. Особливу увагу приділено гендерним, віковим і професійним характеристикам мігрантів, а також структурним викликам, з якими вони стикаються, таким як доступ до освіти, мовні бар'єри, інтеграція на ринку праці та соціальна інклюзія.

Методи. У дослідженні використано комбінацію статистичного аналізу, огляду політики та тематичних досліджень випадків у вибраних країнах ЄС, щоб забезпечити науково обґрунтований погляд на динаміку міграції та політичні заходи реагування.

Результати. Досліджено наслідки динаміки міграції для ЄС, включаючи демографічний тиск, дефіцит робочої сили в певних секторах, навантаження на державні послуги та необхідність адаптації національної та загальноєвропейської міграційної політики. В ній аналізується, як приймаючі країни реагують на інтеграцію українських біженців і трудових мігрантів, оцінюється готовність систем освіти, ринків праці та соціальної інфраструктури до боротьби зі стійким напливом. У статті оцінено стратегії уряду України щодо управління міграцією та межі співпраці з європейськими інституціями. Тут обговорено потенційні довгострокові наслідки міграції для людського капіталу України, включаючи відтік мізків і втрату кваліфікованої робочої сили, а також можливості для циркулярної міграції та залучення діаспори.

Висновки. На основі отриманих результатів запропоновано рекомендації, засновані на даних, спрямованих на побудову більш узгодженої, інклюзивної та сталої міграційної політики. Ці результати покликані підтримати формулювання обґрунтованої політики як в Україні, так і в ЄС у ширшому контексті регіональної стабільності, розвитку освіти та соціально-економічної стійкості.

Ключові слова: міграційні процеси, українські мігранти, внутрішні переміщення, трудова міграція, інтеграційна політика, Європейський Союз, соціально-економічний вплив.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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MATHEMATICAL MODELING OF INFLATION PROCESSES IN THE ECONOMY USING DIFFERENTIAL EQUATIONS WITH FRACTIONAL DERIVATIVES

Background. When studying rapidly changing inflationary processes in economics, theoretical methods based on ordinary differential equations or partial differential equations are often used. However, as demonstrated in this paper, in certain cases it is more appropriate to use the apparatus of differential equations with fractional derivatives. This is due to the presence of various types of nonlinearities in functional relationships within inflationary processes, the influence of parameter values from previous time points on current values, the existence of scaling relations, and so on. In fact, all these characteristics are inherent to fractional calculus.

Methods. The article is devoted to the application of differential equations with fractional derivatives of Caputo for the analysis of inflationary (deflationary) processes in the economy, based on the method of measuring inflation using the consumer price index, which takes into account changes in prices for a certain set of goods and services. This is demonstrated by changes in the specified index over finite time periods.

Results. It is shown that the use of fractional order differential equations can be useful for building flexible tools for forecasting inflation/deflation processes. The relationship between the inflation rate and the unemployment rate is also investigated.

Conclusions. It has been established that the change in the fractional derivative index in theoretical models of economic processes allows describing different regimes of price dynamics – from moderate inflation to galloping and hyperinflation, as well as complex deflationary scenarios. The appearance of negative values of price indices for individual goods can be interpreted as a consequence of their excess production, which leads to a loss of market value. The proposed method of using differential equations with fractional values of the order of derivatives provides an expansion of the possibilities of modeling a wide range of economic processes.

Keywords: inflationary (deflationary) processes in the economy, price index, rate of price change, unemployment rate, Caputo's fractional derivatives, and differential equations with these derivatives.

Background

In the modern economic environment, one of the key problems is inflation (Bossone, 2019; Dinh, 2020; Conrad, 2022; Lester, 2023; Afrouzi, 2024; Dibyendu, & Chandra, 2025; Ferraris, 2025). This phenomenon reflects the growth of the general level of prices for goods and services, which has a significant impact on the stability of financial systems and the socio-economic development of countries as a whole. The growth of prices and its consequences, such as the decline in the standard of living of the population and the deterioration of the macroeconomic situation, become the object of in-depth analysis and the search for optimal management strategies.

Researchers and practitioners draw attention to the importance of developing new methods and analytical tools for analyzing and forecasting inflationary phenomena. The relationship between inflation (deflation) and unemployment, and other economic indicators, is becoming a relevant task for economic science and practice.

The paper aims to achieve a more realistic and adaptive modeling of various types of inflationary processes using differential equations with fractional Caputo derivatives.

Literature review. The complex processes of inflation require the construction of various mathematical models for a deeper understanding. These models make it possible to

predict such processes and to influence them through their interconnections with various economic and political decisions. For instance, in (Moza, Brandibur, & Găină, 2023), the relationship between interest rates, investment demand, and the inflation rate is studied using a four-dimensional model that describes these interactions by applying a control law to the interest rate. In (Ifeacho, & González-Parra, 2025), a mathematical model is proposed based on a system of first-order nonlinear differential equations, developed to study the impact of corruption, unemployment, and inflation on economic growth (it also considers numerical simulations where periodic solutions arise due to Hopf bifurcation). In works (Tsoularis, 2021; Navarro, & Tomé, 2022), economic models are also analyzed using ordinary differential equations, often allowing for single-factor approximations.

However, when modeling multifactor processes (for example, in the Black-Scholes model for option pricing), describing the dynamics of economic processes and systems (for example, in the analysis of inflationary processes in the economy), the possibility of describing optimal solutions, etc., partial differential equations provide greater flexibility, multidimensionality, and accuracy of approaches to mathematical modeling (see Alam, 2020; Neumann, 2022; Ashish, 2025; Kubba, & Abdou, 2025).

In particular, in recent years, differential equations with fractional derivatives have been increasingly used in economics (see, for example, (Dąbrowski, Janus, & Mucha, 2025; Saeidi, Hejazi, & Mohammadi, 2024; Tarasova, & Tarasov, 2017; Luo, Wang, & Fečkan, 2018; Ming, Wang, & Fečkan, 2019; Tarasov, 2020a, 2020b; Awa, 2020; Muhamad et al., 2021; Badi'k, & Fečkan, 2021; Cheow et al., 2024; Kocapor, Valério, & Radonjić, 2025)). Unlike ordinary differential equations and partial differential equations, fractional equations allow for modeling processes that take memory effects into account (for instance, in financial markets, prices are influenced not only by current news but also by previous trends and expectations). Fractional differential equations provide a smoother transition between linear and nonlinear growth, between stability and instability, which is important for modeling complex economic systems with many interdependent factors. Models with fractional derivatives tend to align better with empirical data than those based on conventional derivatives. Fractional derivatives also account for anomalous diffusion and time delays, which are crucial for adapting to economic situations with nonstandard dynamics – such as crises or long-term cycles. Since the economy encompasses various time scales – short-term fluctuations, medium-term cycles, and long-term trends – it makes sense to use fractional differential equations, as they can simultaneously account for the influence of all these scales. It should be noted that the order of a fractional derivative can be an arbitrary real number (and even an arbitrary complex number or a complex-valued function of a complex variable), which provides greater flexibility in tailoring models to specific problems. In this work, it will be shown that by varying the order of a Caputo-type fractional derivative, it is possible to describe different types of inflation in a unified manner. Finally, fractional equations naturally reflect so-called scaling properties, as they exhibit a self-similar (fractal) structure. Solutions to fractional equations often involve functions of the Mittag-Leffler type, which are characteristic of power-law distributions (for example, income distributions, company sizes, and price fluctuations).

In the works (Luo, Wang, & Fečkan, 2018; Ming, Wang, & Fečkan, 2019; Tarasov, 2020a, 2020b; Kocapor, Valério, & Radonjić, 2025), when analyzing statistical data on economic growth, respectively, in Spain, China, and Serbia, it was shown that the use of the fractional Caputo derivative leads to better results than when using derivatives of integer orders. It is obvious that using differential equations with fractional derivatives (in particular, the fractional Caputo derivative), it is possible to model inflationary (deflationary) processes, which we will briefly recall here.

Methods

A brief description of different types of inflation.

Inflation can be given a fairly concise and extremely capacious definition: inflation – an increase in the general (average) price level over time (Bossone, 2019; Dinh, 2020; Conrad, 2022; Lester, 2023; Afrouzi, 2024; Dibyendu, & Chandra, 2025; Ferraris, 2025).

According to the rate of price growth, there are three types of inflation: moderate, galloping, and hyperinflation.

1) Moderate, or creeping, inflation occurs when prices in the country grow by an average of up to 10% per year. This type of inflation is considered safe, and when prices increase by only a few percent, it is even desirable. A slight increase in prices has a stimulating effect on economic entities, so to speak, "whips up" their business activity. The activation of demand, accordingly, stimulates production.

2) Galloping inflation occurs when prices increase by more than 10% per year (approximately 100 – 200%). This type of inflation becomes dangerous because when prices jump, people lose their composure, each time expecting another price increase.

3) Hyperinflation (from the Greek *hyper* – above) – the most dangerous type of inflation. During hyperinflation, prices grow extremely quickly; they seem to explode, reaching astronomical heights, for example, more than 1000% per year, or 50% per month, or 1% per day. This is self-accelerating inflation.

It should also be noted that with inflationary processes of price increases, there is a tendency to decrease prices (general or for individual types of goods). This process is called deflation. Deflation is caused by a shortage of money compared to the production of goods. This leads to a decrease in the rate of inflation – disinflation.

It is important to characterize the dynamics of the considered inflationary processes, both in discrete and continuous time, using the main quantitative characteristics (price indices for various goods, rates of change of these prices, the general core inflation index, the general inflation rate, etc.), to which we proceed in detail.

Formulation of the Cauchy problem for the consumer price index. One of the main indicators of inflation is the consumer price index (CPI), which reflects changes in prices for a certain set of goods and services (Ferraris, 2025; Vilenskyi, Lyvshits, & Smolyak, 2011). Based on this indicator, this article proposes a method for studying inflation processes using fractional order differential equations. However, before proceeding to the direct description of this method, it is demonstrated here how it is possible to first obtain an ordinary and fairly simple partial differential equation based on the analysis of the price index, and then make the transition to a fractional derivative differential equation.

The price index $J_k(t, s)$ for a good k for the period from time s to time t is the ratio of the price $P_k(t)$ at time t to the price $P_k(s)$ at time s :

$$J_k(t, s) = P_k(t) / P_k(s). \quad (1)$$

In the case when the time point s is taken as the initial time point $t = 0$, the corresponding price index is called the base price index. Two main properties of base indices follow from the definition:

1) Reversibility: for any time instants t and s the equality holds:

$$J_k(t, s) = 1 / J_k(s, t). \quad (2)$$

Obviously, as follows from (2), for any t the equality holds $J_k(t, t) = 1$.

2) Transitivity: if $t_1, t_2, \dots, t_m$ are arbitrary moments of time, then the following relation holds:

$$J_k(t_m, t_1) = J_k(t_2, t_1) \cdot J_k(t_3, t_2) \cdot \dots \cdot J_k(t_m, t_{m-1}). \quad (3)$$

Let us now turn to the consideration of the rate of change of the price $i_k(t)$ of product k at time t . The rate of change of the price of product k for the period from time t to time $t + \Delta$ is called the quantity

$$i_k(t + \Delta, t) = [P_k(t + \Delta) - P_k(t)] / P_k(t) \Delta. \quad (4)$$

Dividing the numerator and denominator of the right-hand side of expression (4) by $P_k(s)$, taking into account (1), we obtain that for a given base time s , the value of the rate of

change in the price of product k for the period from time t to time can be written in the following form:

$$i_k(t + \Delta, s) = [J_k(t + \Delta, s) - J_k(t, s)] / J_k(t, s) \Delta. \quad (4a)$$

Expression (4a) is convenient because the price indices in it are reduced to a common base time point s . To obtain the rate of change of the price of product k at time point t , in (4a) we perform a limit transition by $\Delta \rightarrow 0$:

$$i_k(t, s) = \lim_{\Delta \rightarrow 0} [J_k(t + \Delta, s) - J_k(t, s)] / J_k(t, s) \Delta = \frac{1}{J_k(t, s)} \frac{\partial J_k(t, s)}{\partial t} = \frac{\partial}{\partial t} \ln J_k(t, s). \quad (5)$$

As follows from formula (1), the right-hand sides of formulas (4a) and (5) do not really depend on the base time s . The main question is under what conditions the rate of price change $i_k(t, s)$ will depend only on the current time t and will not depend on the base time s . The answer is given by the following statement.

If for any step m the price index (hereinafter also the inflation index) $J_k(t, s)$ satisfies the transitivity condition (3), then the quantity $i_k(t, s)$ does not depend on s . Then the correct notation is $i_k(t)$. And, conversely, if $i_k(t, s)$ does not depend on s and it is known that for $J_k(t, s)$ (not necessarily given by formula (1)) the condition $J_k(t, t) = 1$ is fulfilled, then satisfies $J_k(t, s)$ the transitivity condition (3) (for a proof of these statements by induction (Vilenskyi, Lyvshits, & Smolyak, 2011)).

Thus, for a price index defined in accordance with formula (1) (or for any other inflation indices that satisfy condition (3)), the rate of price change, as well as the inflation rate, is calculated by the formula

$$i_k(t) = \frac{1}{J_k(t, s)} \frac{\partial J_k(t, s)}{\partial t}. \quad (6)$$

The dimension of the rate of price change is 1/unit of time or %/unit of time (for example, % per year or % per month). Equation (6) is rewritten as follows:

$$\partial J_k(t, 0) / \partial t = i_k(t) J_k(t, 0). \quad (7)$$

Being interested in the change in the price index $J_k(t, 0)$ of the k -th product over a finite time interval $[0, T]$, we introduce the relative time $\tau = t/T$. As a result, equation (7) is rewritten as

$$\partial J_k(\tau) / \partial \tau = i_k(\tau) T J_k(\tau), \quad (8)$$

where $J_k(\tau, 0) \equiv J_k(\tau)$. Assuming that the price of some k -th good during inflation can both increase and decrease, equation (8) is generalized to the following:

$$\partial J_k^{(\pm)}(\tau) / \partial \tau = \pm i_k(\tau) T J_k^{(\pm)}(\tau). \quad (8a)$$

Adding to it the initial condition $J_k^{(\pm)}(0) = 1$, we proceed to the following Cauchy problem:

$$\partial J_k^{(\pm)}(\tau) / \partial \tau = \pm \lambda_k(\tau) J_k^{(\pm)}(\tau), \quad J_k^{(\pm)}(0) = 1, \quad (9)$$

where $\lambda_k(\tau) = i_k(\tau) T$ is the dimensionless rate of change in the price of the k -th product over the time interval $[0, T]$. Solving problem (9) using the separation of variables method, we obtain the exponential growth (decrease) of the price index $J_k^{(\pm)}(\tau)$ depending on the relative time τ :

$$J_k^{(\pm)}(\tau) = \exp\left[\pm \int_0^\tau \lambda_k(\tau) d\tau\right]. \quad (10)$$

It is obvious that at $\lambda_k(\tau) = 0$ from (10) we obtain $J_k^{(\pm)}(\tau) = 1$, i.e. we have the case of a constant price of the k -th good (no inflation). If $\lambda_k(\tau) = \text{const} \equiv i_k T = \lambda_k$, then from (10) we obtain

$$J_k^{(\pm)}(\tau) = \exp(\pm \lambda_k \tau), \quad (11)$$

that is, we have an exponential nature of the increase (decrease) in the price of the k -th good. Other functions $\lambda_k(\tau)$ can be taken if the rate of change itself changes in the process of inflation. However, there is another approach to the analysis of inflationary processes, which is based on the use of fractional derivatives (Caputo, & Mainardi, 1971; Samko, Kilbas, & Marichev, 1993; Kilbas, Srivastava, & Trujillo, 2006). In particular, in the future we will analyze various inflationary processes using differential equations with fractional derivatives (Caputo, & Mainardi, 1971; Kilbas, Srivastava, & Trujillo, 2006).

So, using the definition and properties of the consumer price index as one of the main indicators of the inflation process, and the justification of partial differential equations (8), (8a), and their solutions (10), (11), we proceed to the following generalization.

Consideration of inflationary processes using differential equations with fractional derivatives.

Assuming that $\lambda_k(\tau) = \lambda_k$, from equations (8) and (8a) we proceed to the following differential equations with fractional derivatives:

$$\partial^\alpha J_k(\tau) / \partial \tau^\alpha = \lambda_k J_k(\tau), \quad (12)$$

$$\partial^\alpha J_k^{(\pm)}(\tau) / \partial \tau^\alpha = \pm \lambda_k J_k^{(\pm)}(\tau), \quad (12a)$$

where $n-1 < \alpha < n$, $n=1, 2, \dots$ (note that by changing the exponent of the fractional derivative α , as will be shown below, we can describe different inflation rates). Note also that as a fractional derivative $\partial^\alpha / \partial \tau^\alpha$ we will consider the left-hand fractional derivative of Caputo (Caputo, & Mainardi, 1971; Kilbas, Srivastava, & Trujillo, 2006):

$${}^C D_a^\alpha f(\tau) = \frac{1}{\Gamma(n-\alpha)} \int_a^\tau (\tau-t)^{n-\alpha-1} f^{(n)}(t) dt = {}^R D_a^\alpha f(\tau) - \sum_{k=0}^{n-1} \frac{f^{(k)}(0)}{\Gamma(k-\alpha+1)} (\tau-a)^{k-\alpha}, \quad (13)$$

where is the fractional Riemann – Liouville derivative (Kilbas, Srivastava, & Trujillo, 2006).

Results

Therefore, using (13) at $a=0$ equation (12a) is rewritten as follows:

$${}^C D_0^\alpha J_k^{(\pm)}(\tau) \mp \lambda_k J_k^{(\pm)}(\tau) = 0, \quad (\tau > 0; n-1 < \alpha < n; n \in \mathbb{N}; \lambda_k \in \mathbb{R}). \quad (14)$$

Let's move on to analyzing the solutions of this fractional differential equation. In the case $0 < \alpha < 1$ the solution to equation (14) under the initial condition, as in equation (9), is the following function (Kilbas, Srivastava, & Trujillo, 2006):

$$J_k^{(\pm)}(\tau) = E_{\alpha, 1}(\pm \lambda_k \tau^\alpha), \quad (15)$$

where $E_{\alpha, \beta}(x) = \sum_{k=0}^{\infty} [x^k / \Gamma(\alpha k + \beta)]$ is the Mittag – Leffler function (Samko, Kilbas, & Marichev, 1993; Kilbas, Srivastava, & Trujillo, 2006). Appendix A discusses in detail the algorithm

for solving equations of type (14). It is obvious that at $\alpha = 1$ the solution (15) will coincide with the function (11). Such functions of price indices for products with different inflation (deflation) rates are convenient for describing the processes of moderate (creeping) inflation (deflation).

In Fig. 1a, b, respectively, on finite time intervals $0 \leq \tau \leq 1$ and $0 \leq \tau \leq 10$ plots of the price index function are plotted, respectively, for the following values of the dimensionless rate of change in the price of the k -th product and the indices α of the fractional derivative: $\lambda_k = 0, \pm 0.17$, $\alpha = 1, 0.9, 0.7, 0.5$

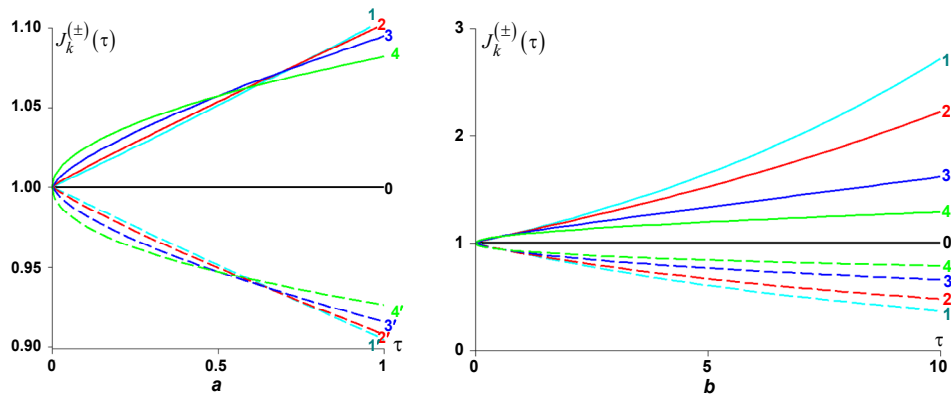


Fig. 1. Plots of the price index functions $J_k^{(\pm)}(\tau)$ of the k -th product at $0 \leq \tau \leq 1$ (a), $0 \leq \tau \leq 10$ (b)

for the cases $\lambda_k = 0$ – line 0; $\alpha = 1$ – curves 1, 1'; $\alpha = 0.9$ – curves 2, 2'; $\alpha = 0.7$ – curves 3, 3'; $\alpha = 0.5$ – curves 4, 4'

From Fig. 1a it is seen that for curves with smaller values of the indicator α to some values of times τ price indices will be higher than for curves with larger values of α . Then an inverse situation arises, when with lower indicators α there will be lower price indicators. As can be seen from Fig. 1b, this trend does not change even with further growth values of τ . It is obvious that here the nonlinear behavior of price indices (for example, for a specific product k) with changes in the inflation rate is manifested. For deflationary processes, as can be seen from Fig. 1a, b, the situation will be almost mirror-image for small values of τ and is strongly disturbed with increasing values of τ .

In the case $1 < \alpha < 2$ under initial conditions $J_k^{(\pm)}(0) = 1$ and $\partial J_k^{(\pm)}(0)/\partial \tau = \pm \lambda_k$ the solution to equation (14) is written in the following form (Kilbas, Srivastava, & Trujillo, 2006):

$$J_k^{(\pm)}(\tau) = E_{\alpha,1}(\pm \lambda_k \tau^\alpha) \pm \lambda_k \tau E_{\alpha,2}(\pm \lambda_k \tau^\alpha). \quad (16)$$

In Fig. 2a, plots of price index functions $J_k^{(\pm)}(\tau)$ are plotted over a time interval $0 \leq \tau \leq 1$ for the same value λ_k and for the values of $\alpha = 1, 1.3, 1.5, 1.7$. In Fig. 2b plots of the price index function $J_k^{(\pm)}(\tau)$ for the same λ_k and α are plotted over a time interval $0 \leq \tau \leq 10$ (these functions $J_k^{(-)}(\tau)$ are examined separately below).

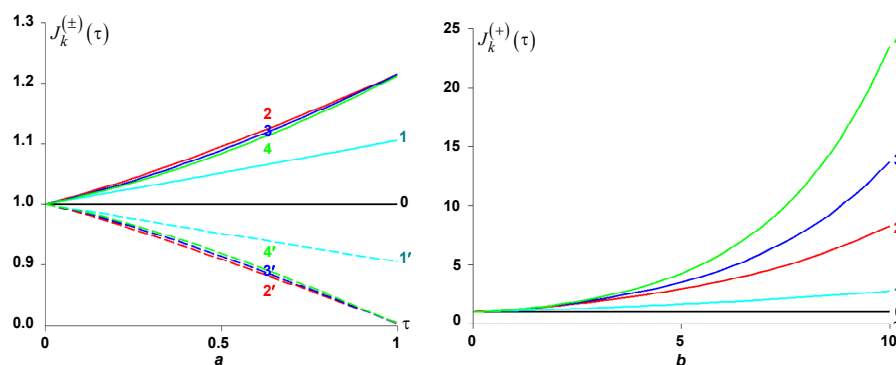


Fig. 2. Plots of the price index functions $J_k^{(\pm)}(\tau)$ of the k -th product at $0 \leq \tau \leq 1$ (a), $0 \leq \tau \leq 10$ (b) for the cases $\lambda_k = 0$ – line 0; $\alpha = 1$ – curves 1, 1'; $\alpha = 1.3$ – curves 2, 2'; $\alpha = 1.5$ – curves 3, 3'; $\alpha = 1.7$ – curves 4, 4'

As can be seen from Fig. 2a, the curves $J_k^{(+)}(\tau)$ with $1 < \alpha < 2$ pass above the curve with $\alpha = 1$ (in the case of inflation), and the curves $J_k^{(-)}(\tau)$ with $1 < \alpha < 2$ pass below

the curve with $\alpha = 1$ (in the case of deflation). In this case, the behavior of the curves is similar to the behavior of the curves in Fig. 1a, namely, the curves with smaller values of α are initially located above the curves with larger values of α , and then they change places, which is a manifestation

of the non-linearity of the functions (16). Note that using the function $J_k^{(+)}(\tau)$ processes with galloping inflation can be described (see Fig. 2b), and using the function $J_k^{(-)}(\tau)$ processes with galloping deflation can be described.

To describe hyperinflation we use the solutions of equation (14) at $2 < \alpha < 3$ and under initial conditions $J_k^{(+)}(0) = 1$, $\partial J_k^{(+)}(0)/\partial \tau = \lambda_k$ and $\partial^2 J_k^{(+)}(0)/\partial \tau^2 = \lambda_k^2$ (Kilbas, Srivastava, & Trujillo, 2006):

$$J_k^{(+)}(\tau) = E_{\alpha,1}(\lambda_k \tau^\alpha) + \lambda_k \tau E_{\alpha,2}(\lambda_k \tau^\alpha) + \lambda_k^2 \tau^2 E_{\alpha,3}(\lambda_k \tau^\alpha). \quad (17)$$

Fig. 3 plots the function (17) for different values of the fractional derivative exponent (it is seen that with a change in the value of α in the interval, the function $J_k^{(+)}(\tau)$ increases sharply over time).

Finally, in Fig. 4a, b plots of the function $J_k^{(-)}(\tau)$ are plotted for those values of α that were chosen, respectively, when constructing the function $J_k^{(+)}(\tau)$ in Fig. 2b, Fig. 3 (in Fig. 4a, the time interval $0 \leq \tau \leq 50$ was chosen, and in Fig. 4b, the time interval $0 \leq \tau \leq 10$ was chosen,

respectively). In addition, these figures show lines that occur when $\lambda_k = 0$.

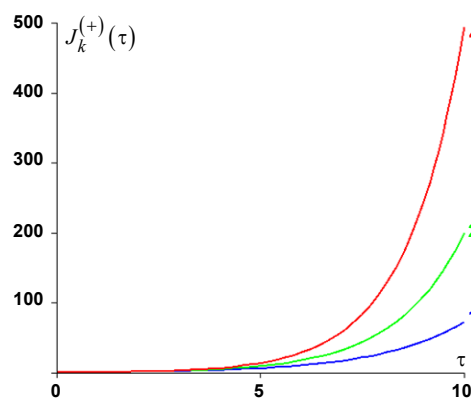


Fig. 3. Plots of the price index functions $J_k^{(+)}(\tau)$ of the k -th product over a time interval $0 \leq \tau \leq 10$ for the cases $\alpha = 2.1$ – curve 1, $\alpha = 2.5$ – curve 2, $\alpha = 2.9$ – curve 3

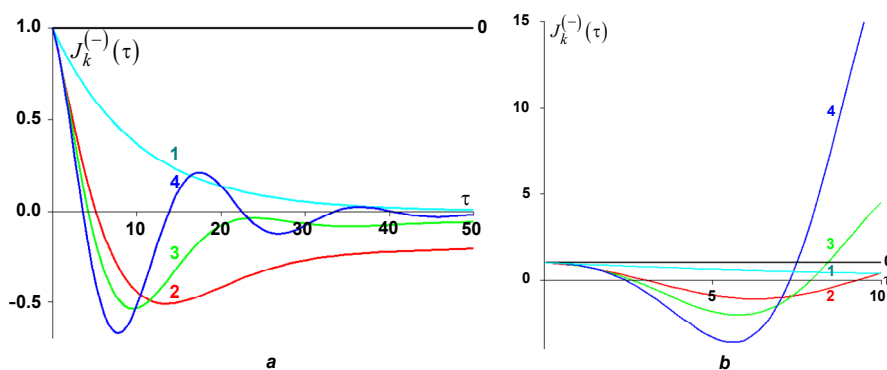


Fig. 4. Plots of the price index functions $J_k^{(-)}(\tau)$ of the k -th product: (a) – at $0 \leq \tau \leq 50$ for $\alpha = 1, 1.3, 1.5, 1.7$ (curves 1, 2, 3, 4); (b) – at $0 \leq \tau \leq 10$ for $\alpha = 1, 2.1, 2.5, 2.9$ (curves 1, 2, 3, 4); at $\lambda_k = 0$ – line 0

Questions arise: how to understand a negative price index $J_k^{(-)}(\tau)$? Are such situations possible? Oddly enough, the answers to these questions can be positive. In this case, we can say that we are dealing with donations, charity, free assistance, etc.

From Fig. 4a, it can also be seen that in the case of galloping deflation, when moving from smaller values of α to larger ones, the change in the price index $J_k^{(-)}(\tau)$ acquires an increasingly pronounced damped oscillatory character. At the same time, this entire oscillatory process in the time interval $0 \leq \tau \leq 50$ occurs at values $J_k^{(-)}(\tau) < 1$ (curves 2 and 3, as can be seen from Fig. 4a, are mainly in the negative region).

Another trend, as can be seen from Fig. 4b, occurs in the case of hyperdeflation, when $2 < \alpha < 3$. In this case, when moving from smaller values of α to larger ones, the price index $J_k^{(-)}(\tau)$ with the change in τ reaches an increasingly smaller negative value. Then as τ increases this index crosses both the abscissa axis and the

dependence $J_k^{(-)}(\tau) = 1$, and then it goes steeper and steeper towards infinity. This means that hyperdeflation transforms into hyperinflation.

Consideration of the relationship between inflation and unemployment over finite time periods using fractional differential equations. Let us now consider the relationship between inflation and the unemployment rate over finite time periods by analyzing solutions of differential equations with fractional derivatives for different values of the indicator α . As is known from the literature (Lester, 2023; Ferraris, 2025), in short-term periods, the relationship between the inflation rate i and the unemployment rate b is described by the Phillips curve. This dependence $i(b)$ demonstrates that as the unemployment rate decreases, the inflation rate increases, i.e., by reducing unemployment, we "pay" with an increase in inflation. Note that the unemployment rate is calculated as the ratio of the number of unemployed people N_{up} registered with the state employment service to the number of working-age population N_{wp} , i.e. $b = N_{up}/N_{wp}$. We also note that the unemployment rate b should generally be much less than unity. However, theoretically, we can also consider situations where the parameter b can reach arbitrary positive values.

It is easy to see from the previous analysis that the simplest Cauchy problem describing such a relationship between inflation and the unemployment rate would be:

$$\frac{\partial i(b)}{\partial b} = -\mu i(b), \quad i(0) = i_0, \quad (18)$$

where the dimensionless quantity μ characterizes the rate of change in the inflation rate with an increase in the unemployment rate, i_0 is inflation in the absence of unemployment. Solving this equation, we obtain $i(b) = i_0 \exp(-\mu b)$. Equation (18) can be generalized by moving on to the following differential equation with fractional Caputo derivative:

$$D_0^\alpha i(b) + \mu i(b) = 0. \quad (19)$$

Using expressions (15)–(17), the solutions of equation (19), for example, for the values $0 < \alpha_1 < 1$, $1 < \alpha_2 < 2$, $2 < \alpha_3 < 3$ are written in the following form:

$$i_1(b) = i_0 E_{\alpha_1,1}(-\mu b^{\alpha_1}). \quad (20a)$$

$$i_2(b) = i_0 \left[E_{\alpha_2,1}(-\mu b^{\alpha_2}) - \mu b E_{\alpha_2,2}(-\mu b^{\alpha_2}) \right]. \quad (20b)$$

$$i_3(b) = i_0 \left[E_{\alpha_3,1}(-\mu b^{\alpha_3}) - \mu b E_{\alpha_3,2}(-\mu b^{\alpha_3}) + \mu^2 b^2 E_{\alpha_3,3}(-\mu b^{\alpha_3}) \right]. \quad (20c)$$

In Fig. 5 plots of functions (20a, b, c) are plotted, for example, for the following numerical values: $i_0 = 0.1$ in the time interval $[0, T]$, $\mu = 1$, $\alpha_1 = 0.5$, $\alpha_2 = 1.5$, $\alpha_3 = 2.5$.

As can be seen from Fig. 5, in addition to curve 1, which corresponds to the Phillips curve (Mankiv, 2000), other relationships between inflation and the unemployment rate are also possible. In particular, in the case of moderate inflation (curve 2), disinflation is higher for small values of b than for $\alpha = 1$, and, on the contrary, it is lower with increasing unemployment.

In the case of galloping inflation (for example, curve 3 in Fig. 5), the function $i(b)$ at a certain unemployment level b_0 reaches a zero value and then, with the increase of b after reaching the minimum value, changes in a weakly oscillating manner in the negative region of its values. Here, an urgent question arises: what do negative values of the inflation rate

mean? As above, when explaining a negative price index, negative values of the function $i(b)$ occur in cases of charitable activities, free assistance, donations, etc.

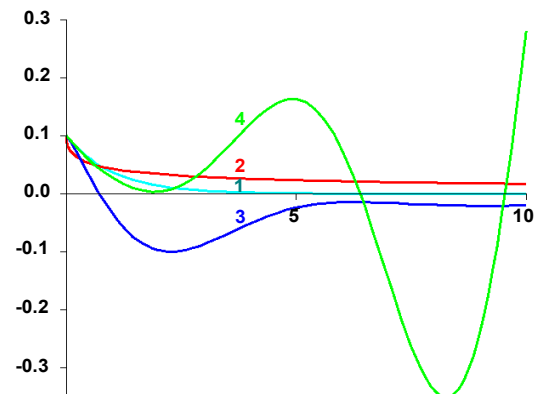


Fig. 5. Plots of the inflation rate function $i(b)$ at $\mu = 1$ and for the following values of α : 1 – curve 1, 0.5 – curve 2, 1.5 – curve 3, 2.5 – curve 4

Finally, in the case of hyperinflation, the function $i(b)$ (for example, curve 4 in Fig. 5) oscillates with increasing amplitude. Thus, as follows from this study, in addition to the traditional monotonic dependence (curve 1) between the unemployment rate and the inflation rate, mathematically admissible and significantly non-monotonic dependences (curves 2, 3, 4) are also significant. Obviously, detailed sociological studies are needed to confirm these non-trivial theoretical results.

It is also interesting to investigate the dependence of the inflation rate functions on the rate of change of the inflation rate for some specific values of unemployment levels. Thus, in Fig. 6a, b for the same values of α as in Fig. 5, graphs of the function $i(\mu)$ are plotted for the following unemployment levels: $b = 0.1$ (see Fig. 6a) and $b = 0.5$ (see Fig. 6b).

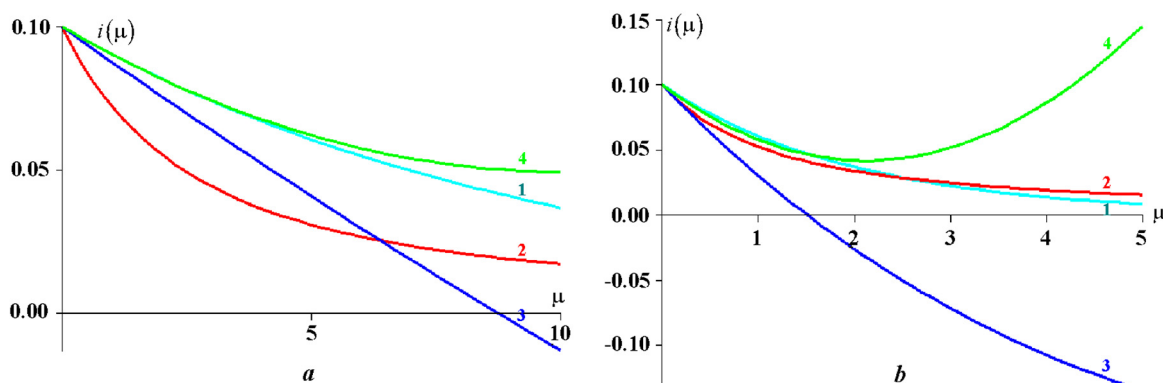


Fig. 6. Plots of the inflation rate function $i(\mu)$ for unemployment levels $b = 0.1$ – (a), $b = 0.5$ – (b) and for the following values of α : 1 – curves 1, 0.5 – curves 2, 1.5 – curves 3, 2.5 – curves 4

From Fig. 6a, b it is seen that the inflation rate function $i(\mu)$ at $\alpha > 1$ is characterized by strong non-monotonicity with increasing inflation rate change rate. It is seen that with increasing unemployment rate, minimum inflation rates are reached at lower inflation rate change rates. In the case of hyperinflation, these rates are the lowest.

Discussion and conclusions

Based on the use of differential equations with fractional derivatives (in particular, with Caputo derivatives), the work investigated changes in the price index, for example, of some k -th commodity (product) at different time intervals. It was shown that when the index α of the fractional derivative

changes, using one fairly simple differential equation, it is possible to describe in a universal way changes in the price index under the influence of different rates of inflation processes, namely, under conditions of moderate, galloping, and hyperinflation. In addition, using this equation, the work also describes deflationary processes at different rates. At the same time, the non-trivial behavior of the obtained solutions may lead over time to the appearance of negative values of price indices (the latter can be explained by the presence of external influences).

Using the same differential equation, one can study the dependence of inflation rates on the unemployment rate at constant rates of change in inflation rates, as well as the dependence of inflation rates on the rates of change in inflation rates at constant inflation levels. It was shown that in addition to the classical Phillips dependence, which is realized at $\alpha = 1$, solutions of the corresponding differential equations with fractional exponents α can give radically different results, which open up prospects for more detailed studies.

Of course, an important point in the study of inflationary processes using differentials with fractional derivatives is the testing of the appropriate methods. Thus, using solutions of differential equations with fractional Caputo derivatives, it is possible to simulate changes in the prices of the main ingredients of the "borscht set" and changes in its average cost under conditions of moderate inflation. For this purpose, the possibility of continuously changing the parameters (in the region $1 < \alpha < 2$) and λ is used to reflect almost periodic changes in inflationary and deflationary periods against the background of general growth. It should be noted that similar dependencies are also found in the work (Lemishovskiy, & Dumych, 2024). It should be noted that for dependencies that describe hyperinflation (see, for example, the work (Tamimi, & Orbán, 2020), the parameters $2 < \alpha < 3$ and λ are easily selected.

Thus, the use of differential equations with fractional derivatives allows for more flexible modeling of complex inflation processes, which, as noted above, is also related to memory effects. In addition, analyzing on the basis of only one equation (with a change only in the order of the fractional derivative and initial conditions) simplifies the work.

The obtained mathematical relationships have the following interpretation:

1) the transition from lower to higher values of the order of the derivative corresponds to an acceleration of the inflation rate;

2) negative values of price indices in the solutions can be interpreted as a consequence of overproduction or changes in external conditions;

3) non-trivial relationships between inflation and unemployment demonstrate the possibility of both classical Phillips behavior and much more complex scenarios that require additional checks;

4) the model can describe the patterns of price fluctuations even under conditions of a variable inflation rate.

The practical significance of the results obtained lies in the possibility of:

1) building flexible tools for forecasting inflationary and deflationary processes;

2) operational monitoring of price indices (for example, for a set of basic food products) in different inflationary regimes;

3) adapting model parameters to specific economic conditions to take into account the influence of external factors (for example, the monetary policy of governments).

Finally, we note that fractional integro-differentiation is increasingly finding its application in various fields of natural science. In particular, in the study of the scattering processes of charged particles that are channeled in crystalline media (Maksyuta, Koshcheev, & Panina, 2012). Interesting results were also obtained when using fractional equations to consider the inflationary theory of the origin of our Universe (Rasoulia et al., 2023).

This is a consequence of the natural process of development/complication of the mathematical apparatus, which is required for a more detailed description of complex phenomena. And complex economic phenomena are no exception.

Appendix A

Using the left-sided fractional Caputo derivative (see formula (13)), we will find the solution to the differential equation

$${}^C D_{0+}^{\alpha} y(t) - \lambda y(t) = 0 \quad (t > 0; n-1 < \alpha \leq n; n \in \mathbb{N}; \lambda \in \mathbb{R}) \quad (A1)$$

using the following integral Laplace transform: using the following integral Laplace transform:

$$(\mathcal{L}y)(s) = \mathcal{L}[y(t)](s) = \int_0^{\infty} y(t) \exp(-st) dt. \quad (A2)$$

Using (A2), the Laplace transform of the fractional Riemann – Liouville derivative has the following form:

$$\begin{aligned} \mathcal{L}[{}^R D_{0+}^{\alpha} y(t)](s) &= \int_0^{\infty} \exp(-st) D_{0+}^{\alpha} y(t) dt = \\ &= \frac{1}{\Gamma(n-\alpha)} \int_0^{\infty} \exp(-st) \left[\frac{d^n}{dt^n} \int_0^t \frac{y(z) dz}{(t-z)^{\alpha-n+1}} \right] dt. \end{aligned} \quad (A3)$$

After integrating by parts n times, expression (A3) will be written as follows:

$$\mathcal{L}[{}^R D_{0+}^{\alpha} y(t)](s) = \frac{s^n}{\Gamma(n-\alpha)} \int_0^{\infty} dt \int_0^t \frac{\exp(-st) y(z) dz}{(t-z)^{\alpha-n+1}}. \quad (A4)$$

Using the well-known Dirichlet formula

$$\int_a^b dx \int_a^x f(x, y) dy = \int_a^b dy \int_y^b f(x, y) dx$$

and moving to a new variable $w = t - z$, we continue with the following transformations:

$$\begin{aligned} \mathcal{L}[{}^R D_{0+}^{\alpha} y(t)](s) &= \frac{s^n}{\Gamma(n-\alpha)} \int_0^{\infty} y(z) dz \int_z^{\infty} \frac{\exp(-st) dt}{(t-z)^{\alpha-n+1}} = \\ &= \frac{s^n}{\Gamma(n-\alpha)} \int_0^{\infty} y(z) dz \int_0^{\infty} \frac{\exp[-s(z+w)] dw}{w^{\alpha-n+1}} = \\ &= \frac{s^n}{\Gamma(n-\alpha)} \int_0^{\infty} y(z) \exp(-sz) dz \int_0^{\infty} \exp(-sw) w^{\alpha-n-1} dw = \\ &= \left| \begin{matrix} sw = x, w = x/s \\ dw = dx/s \end{matrix} \right| \frac{s^n}{\Gamma(n-\alpha)} \int_0^{\infty} y(z) \exp(-sz) dz \int_0^{\infty} \exp(-x) x^{\alpha-n-1} dx = \\ &= s^{\alpha} \int_0^{\infty} y(z) \exp(-sz) dz = s^{\alpha} (\mathcal{L}y)(s). \end{aligned} \quad (A5)$$

We now find the Laplace transform of the second term in formula (13) under the condition $a = 0$:

$$\begin{aligned} \mathcal{L} \left[\sum_{k=0}^{n-1} \frac{y^{(k)}(0)}{\Gamma(k-\alpha+1)} t^{k-\alpha} \right] (s) &= \\ \sum_{k=0}^{n-1} \frac{y^{(k)}(0)}{\Gamma(k-\alpha+1)} \int_0^{\infty} \exp(-st) t^{k-\alpha} dt &= \left| \begin{matrix} st = x, t = x/s \\ dt = dx/s \end{matrix} \right| = \\ = \sum_{k=0}^{n-1} \frac{y^{(k)}(0) s^{\alpha-k-1}}{\Gamma(k-\alpha+1)} \int_0^{\infty} \exp(-x) x^{k-\alpha} dx &= \sum_{k=0}^{n-1} y^{(k)}(0) s^{\alpha-k-1}. \end{aligned} \quad (A6)$$

Therefore, subtracting expression (A6) from expression (A5), we arrive at the following Laplace transform of the fractional Caputo derivative

$$\mathcal{L}[{}^C D_{0+}^\alpha y(t)](s) = s^\alpha \mathcal{L}[y(t)](s) - \sum_{j=0}^{n-1} d_j s^{\alpha-j-1}, \quad (\text{A7})$$

where $d_j = y^{(j)}(0)$, $(j = 0, \dots, n-1)$. Now applying (A2) and (A7) to equation (A1), we obtain

$$\mathcal{L}[y(t)](s) = \sum_{j=0}^{n-1} d_j \frac{s^{\alpha-j-1}}{s^\alpha - \lambda}. \quad (\text{A8})$$

On the other hand, it is easy to show that the following formula holds:

$$\mathcal{L}[t^j E_{\alpha, j+1}(\lambda t^\alpha)](s) = \frac{s^{\alpha-j-1}}{s^\alpha - \lambda} \quad (|s^{-\alpha} \lambda| < 1). \quad (\text{A9})$$

Let's prove this formula:

$$\begin{aligned} \mathcal{L}[y_j(t)](s) &= \int_0^\infty t^j E_{\alpha, j+1}(\lambda t^\alpha) \exp(-st) dt = \\ &= \sum_{k=0}^\infty \frac{\lambda^k}{\Gamma(\alpha k + j + 1)} \int_0^\infty t^{\alpha k + j} \exp(-st) dt. \end{aligned} \quad (\text{A10})$$

Further performing a linear substitution $st = x$ in the integral of formula (A10), we obtain

$$\begin{aligned} \int_0^\infty t^{\alpha k + j} \exp(-st) dt &= \left| \begin{matrix} x = st, t = x/s \\ dt = dx/s \end{matrix} \right| = \\ &= \frac{1}{s^{\alpha k + j + 1}} \int_0^\infty x^{\alpha k + j} \exp(-x) dx = \frac{\Gamma(\alpha k + j + 1)}{s^{\alpha k + j + 1}}. \end{aligned} \quad (\text{A11})$$

Substituting (A11) into (A10), we obtain

$$\mathcal{L}[y_j(t)](s) = \frac{1}{s^{j+1}} \sum_{k=0}^\infty (\lambda s^{-\alpha})^k. \quad (\text{A12})$$

From formula (A12) it is clear that the power series present in it is a geometric progression with denominator $q = \lambda s^{-\alpha}$. It is obvious that under the condition $|\lambda s^{-\alpha}| < 1$ we have

$$\sum_{k=0}^\infty (\lambda s^{-\alpha})^k = \frac{1}{1 - \lambda s^{-\alpha}} = \frac{s^\alpha}{s^\alpha - \lambda}. \quad (\text{A13})$$

So, after substituting (A13) into formula (A12) under the condition $|\lambda s^{-\alpha}| < 1$ we arrive at formula (A9). Thus, from relations (A8) and (A9) it follows that the solution of equation (A1) is represented in the following form:

$$y(t) = \sum_{j=0}^{n-1} d_j y_j(t), \quad (\text{A14})$$

where $y_j(t) = t^j E_{\alpha, j+1}(\lambda t^\alpha)$, $(j = 0, \dots, n-1)$ is the fundamental system of solutions of equation (A1).

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МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ ІНФЛЯЦІЙНИХ ПРОЦЕСІВ В ЕКОНОМІЦІ ЗА ДОПОМОГОЮ ДИФЕРЕНЦІАЛЬНИХ РІВНЯНЬ ІЗ ДРОБОВИМИ ПОХІДНИМИ

Вступ. Під час вивчення швидкозмінних інфляційних процесів в економіці часто використовують теоретичні методи, засновані на звичайних диференціальних рівняннях або диференціальних рівняннях із частинними похідними. Однак, як показано в цій статті, у певних випадках доцільніше застосовувати апарат диференціальних рівнянь із дробовими похідними. Це пов'язано з наявністю різних типів нелінійностей у функціональних зв'язках у межах інфляційних процесів, впливом значень параметрів із попередніх моментів часу на поточні значення, існуванням співвідношень масштабування тощо. Фактично, всі ці характеристики притаманні дробовому численню.

Методи. Статтю присвячено застосуванню диференціальних рівнянь із дробовими похідними Капуто для аналізу інфляційних (дефляційних) процесів в економіці, базуючись на методі вимірювання інфляції з використанням індексу споживчих цін, який враховує зміни у цінах на певний набір товарів і послуг. Це продемонстровано на змінях зазначеного індексу на скінченних часових відрізках.

Результати. Показано, що використання диференціальних рівнянь дробового порядку може бути корисним для побудови гнучких інструментів прогнозування процесів інфляції / дефляції. Також досліджено зв'язок між рівнем інфляції та рівнем безробіття.

Висновки. Встановлено, що зміна індексу дробової похідної в теоретичних моделях економічних процесів дозволяє описувати різні режими цінової динаміки – від помірної інфляції до галопуючої та гіперінфляції, а також складні дефляційні сценарії. Поява від'ємних значень індексів цін на окремі товари може бути інтерпретована як наслідок їх надлишкового виробництва, що призводить до втрати ринкової вартості. Запропонований метод використання диференціальних рівнянь із дробовими значеннями порядку похідних забезпечує розширення можливостей моделювання широкого спектра економічних процесів.

Ключові слова: інфляційні (дефляційні) процеси в економіці, індекс цін, темпи зміни цін, рівень безробіття, дробові похідні Капуто та диференціальні рівняння із цими похідними.

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INTEGRATION OF CIRCULAR ECONOMY AND RESILIENCE PRINCIPLES INTO STATE ANTI-CRISIS POLICY AND CORPORATE STRATEGIES

Background. Modern global challenges – from climate change to armed conflicts – have intensified the search for new economic models capable of combining the objectives of sustainable development with the enhancement of the resilience of societies and economies. The purpose of the study is to systematize theoretical approaches to the formation of new economic models of sustainable development and resilience, to determine their potential for strengthening the economic security of the state and enterprises, as well as to substantiate the possibilities of integrating the principles of the circular economy and resilience into state anti-crisis policy and corporate strategies using Ukraine as a case study. At the core of the research hypothesis lies the assumption that the spread of sustainable and resilient development practices among Ukrainian enterprises directly influences the country's economic security, shaping its ability to withstand military and global risks.

Methods. Analysis and synthesis, generalization; structural and functional analysis method; graphical and tabular methods.

Results. In the course of the study, a typology of new economic models (green, circular, frugal, solidarity, creative, etc.) was carried out, and their potential to ensure resilience and post-crisis economic recovery was analyzed. Particular attention was paid to the circular economy principles, which are considered an institutional basis for strengthening anti-crisis regulation and long-term economic security. The empirical part of the study is based on the analysis of sustainable development practices of the 22 largest Ukrainian enterprises from six industries, which demonstrate high adaptability during wartime. Among the most widespread practices are employee and community support, assistance to the Armed Forces of Ukraine, as well as ecological modernization of production. On this basis, key components of sustainable development that directly affect the economic security of the state were identified, and indicators were proposed for assessing the contribution of business to ensuring resilience.

Conclusions. The results confirmed the research hypothesis: sustainable development practices in wartime strengthen the economic security of the state and form the foundation for inclusive post-crisis recovery. The study combines the systematization of theoretical models with an applied analysis of corporate strategies, which ensures its scientific novelty and practical significance. Prospects for further research are related to the development of integrated methodologies for assessing economic resilience, digital support for circular practices, and the harmonization of Ukrainian sustainability standards with those of the European Union.

Keywords: circular economy, economic security, resilience, regulatory framework, post-war recovery, social responsibility, fiscal regulation, macroeconomic stability.

Background

Modern global challenges – ranging from climate change to armed conflicts – have intensified the search for new economic models capable of combining the objectives of sustainable development with the enhancement of societal and economic resilience (Zalilo, 2025). Traditional growth-oriented approaches are increasingly giving way to concepts that take into account resource constraints, social inclusiveness, and the capacity of systems to recover after crises. In this context, models such as the green, circular, frugal, solidarity, and creative economies have gained traction, each offering its own mechanisms for achieving resilience and economic security. An important complement to these approaches is the integration of fiscal regulation instruments, designed to smooth economic fluctuations and

ensure macroeconomic stability, thereby strengthening the effectiveness of state anti-crisis policies.

These processes are particularly significant for countries operating under extraordinary conditions, such as Ukraine. The full-scale war has created unprecedented challenges for economic development, while simultaneously opening up opportunities to test new approaches to reconciling the objectives of recovery and sustainable growth. The central hypothesis of this study rests on the assumption that the spread of sustainable and resilient development practices among Ukrainian enterprises directly contributes to strengthening national economic security, shaping the state's ability to withstand both military and global risks.

The article seeks to provide both theoretical justification and empirical verification of the interconnection between

new economic models, sustainable development, and economic security. This contribution is significant for advancing scholarly debate as well as informing policy-making in crisis-affected countries. The novelty of the study lies in its combination of the systematization of new economic models with applied analysis of corporate strategies, thereby allowing for an assessment of their tangible contribution to strengthening state resilience.

Purpose and Objectives. The purpose of the study is to systematize theoretical approaches to the formation of new economic models of sustainable development and resilience, to define their role in strengthening the economic security of the state and enterprises, and to substantiate the possibilities for integrating the principles of the circular economy and resilience into state anti-crisis policy and corporate strategies, using Ukraine as a case study.

Achieving this purpose and testing the research hypothesis required addressing the following objectives:

- to examine the role of circular economy and resilience principles in shaping state anti-crisis policy and corporate strategies of Ukrainian enterprises;
- to analyze the main trends in the development of sustainable practices of Ukrainian enterprises during the full-scale war with Russia;
- to identify the core components of enterprise-level sustainable practices that directly influence the economic security and resilience of the state;
- to propose sustainable development indicators (with a focus on employee engagement and support) that demonstrate the contribution of business to the economic security and resilience of the state during wartime.

The object of the study is the process of forming and developing new economic models of sustainable development and resilience, as well as their integration into state anti-crisis policy and enterprise practices under conditions of war and global instability.

Literature review. The analysis of contemporary scholarly research indicates the emergence of new economic models of sustainable development, among which the circular economy occupies a central place as a fundamental model for enhancing economic resilience and security, as well as for adapting the state to crisis challenges.

Research on economic resilience has emerged relatively recently. The earliest studies addressed the conceptual foundations of economic resilience (Rose, 2007) and the resilience of economies following natural disasters (Rose, & Lim, 2002). Since 2020, the concept of regional economic resilience has gained particular prominence (Martin, & Sunley, 2020; Malik, Szewczuk-Stępień, & Bębenek, 2025; Sutton et al., 2023; Tóth et al., 2022). For instance, Malik, Szewczuk-Stępień, and Bębenek (2025) analyze the possibilities of integrating sustainable development principles into the formation of regional resilience plans. The authors argue that sustainability policies should become a fundamental basis for the design of operational measures aimed at strengthening regional resilience. They developed a model of integrated regional resilience, the core element of which is a transformation matrix that enables the translation of strategic sustainable development goals into concrete operational measures and projects, applying the SRP criteria (Safety, Risk, Prevention).

The issue of regional economic resilience has appeared in policy documents of the OECD (2021), the World Bank (2021), the World Trade Organization (2021), and the European Commission (2020). The EU Strategic Foresight Report of 2020 identifies resilience as a new guiding principle for EU policies, emphasizing not only the ability to

withstand threats but also the capacity to undergo transformation in a sustainable, fair, and democratic manner (European Commission, 2020; World Bank Group, 2021).

Scholars have also examined the role of financial incentives in promoting the spread of ESG orientation among enterprises. For instance, Gao, Zhou and Wan (2024) demonstrate that the introduction of green finance policies in China contributed to a significant improvement in corporate ESG performance, a reduction of financial constraints, and the stimulation of investments in sustainable practices. The study underscores the importance of combining state regulation with corporate initiative to achieve the broader goals of sustainable development and resilience.

An important strand of the academic literature focuses on resilience through the implementation of new economic models in sectoral contexts, particularly in resource-intensive industries. Blinova, Ponomarenko and (2022) analyze the concept of corporate sustainability in the mining industry, emphasizing the need to integrate elements of the circular economy into management strategies. In turn, Markevych et al. (2022) argue that the adoption of circular economy principles in the use of mineral resources is directly linked to Ukraine's economic security and forms the foundation for energy and industrial stability.

A substantial body of research has been devoted to the transformation of business models in the context of strengthening state economic security through enhanced corporate resilience. Ensign (2022) emphasizes the importance of business model transformation in achieving the SDGs, while Rosário, Lopes and Rosário (2024) systematize contemporary approaches to combining circularity with sustainable business development. Gazzola et al. (2020) examine the perception of circular economy and sustainability principles in the fashion industry, noting significant differences depending on generation and gender. Al Rashid and Koç (2023) highlight the potential of additive manufacturing (3D printing) for recycling polymer waste, which opens up new opportunities for advancing the circular economy in industry and creating decentralized recycling models.

All of the reviewed publications demonstrate that the circular economy is evolving as a new economic model capable of integrating economic, social, and environmental priorities. It is becoming a key instrument of state anti-crisis policy (IER, 2025), as it reduces dependence on external resources and creates new incentives for domestic development. This model forms the very foundation of economic resilience, since it enables production and financial systems to adapt to global shocks. The implementation of the circular economy ensures economic security by strengthening control over strategic industries and resources in conditions of polycrisis.

Despite the existing scholarly achievements, the examined aspects related to the introduction of conceptually new approaches to safeguarding state economic security and resilience at all levels require further systematic academic reflection. The need to examine economic models in the context of state anti-crisis policy and resilience remains highly relevant. In this regard, the circular economy and alternative scenarios acquire strategic importance, moving beyond the tools of corporate governance and transforming into the basis of state economic policy under crisis and post-crisis recovery conditions.

Methods

To achieve the stated objectives and to test the research hypothesis, the study employed a set of interrelated

methods forming a coherent and logically consistent methodological framework. Their sequential application ensured a gradual transition from theoretical generalization to institutional analysis and empirical verification, thereby strengthening the internal validity and reliability of the research findings. At the first stage, the methods of analysis, synthesis, and generalization were applied to systematize theoretical and conceptual approaches to sustainable development and resilience, to identify the essential features of new economic models, and to outline their evolution in response to global and national crises. These methods provided the epistemological foundation for subsequent analytical procedures. At the next stage, the structural and functional analysis was employed to examine how the principles of the circular economy and resilience can be incorporated into the institutional framework of state anti-crisis policy and mechanisms of economic security. This method made it possible to trace causal linkages between theoretical constructs and the instruments of public regulation, revealing the functional complementarity of economic, social, and environmental dimensions of resilience. At the final stage, graphical and tabular methods were utilized to visualize the interconnections among components of economic security, summarize empirical data on the sustainable practices of Ukrainian enterprises, and ensure clarity and consistency in the presentation of results.

Overall, the methodological design of the study constitutes an integrated system combining theoretical synthesis, structural-functional analysis, and data visualization. The complementarity of these methods allowed for a comprehensive substantiation of the interdependence between sustainable development practices, resilience, and economic security, thus empirically confirming the research hypothesis concerning the integration of circular economy and resilience principles into state anti-crisis policy and corporate strategies.

Results

Integrating Circular Economy and Resilience into State Anti-Crisis Models. In today's conditions of global turbulence driven by wars, economic crises, climate change, and technological transformations, traditional models of economic development are increasingly losing their effectiveness. The resilience of economies depends not only on their ability to withstand shocks but also on their capacity to adapt swiftly, recover, and simultaneously advance along

the path of sustainable development. For this reason, a new generation of economic models is emerging in global scholarly and policy discourse, aimed at ensuring a balance between economic performance, social justice, and environmental security.

The importance of considering these models lies in their ability to provide states and enterprises with new frameworks for building anti-crisis strategies and recovery mechanisms. For instance, the circular economy focuses on closed cycles of production and consumption, prioritizing reuse and waste minimization. The green economy relies on low-carbon technologies and resource efficiency, laying the foundation for "green growth." The frugal economy emphasizes innovations that enable affordable solutions under resource constraints. The social and solidarity economy underscores the significance of collective action, the democratization of economic relations, and the prioritization of social goals over commercial profit. Alongside these, the relevance of creative, blue, purple, and other models is increasing, as they integrate cultural, gender, and environmental dimensions into development strategies.

For economies in transition, such as Ukraine, the systematization of these approaches has both theoretical and practical significance (Sereda, Nahachevska, & Hryhorova, 2024). It enables the identification of models most relevant in the context of post-war recovery, strengthening economic security, and shaping state policies oriented toward resilience. An analysis of the typology of new economic models provides a foundation for selecting effective trajectories of economic development that combine anti-crisis instruments with long-term strategies of sustainability and innovation.

Building on existing scholarly work, the central assumption of this study is that the principles of circularity can serve as an integrative tool for the implementation of new economic concepts of sustainable development (NESD). They provide a practical mechanism for combining ecological, social, and economic dimensions of development, creating conditions for strengthening the resilience of economic systems and their ability to recover after crises. Overall, all the models presented in Table 1 can, within a systems approach, be classified according to their functional orientation as: environmentally oriented models, socially inclusive models, and culturally innovative models (see Fig. 1).

Environmentally Oriented Models	Socially Inclusive Models	Culturally Innovative Models
• Green economy • Blue economy • Frugal/innovation economy	• Social and solidarity economy • Purple/care economy	• Orange/creative economy • Yellow/attention economy

Fig. 1. Classification of new economic models of sustainable development by functional orientation

Source: developed by the author.

New economic models (Fig. 1) integrate the principles of circularity and create prerequisites for ensuring resilience and the recovery of economic systems.

One of the key concepts increasingly regarded as an instrument for shaping new economic models is the circular economy. Its principles – Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover – not only reduce environmental pressures but also enhance the adaptive capacity of economic systems.

Within the framework of state anti-crisis policy, the circular economy acquires particular importance. It allows

not only for resource savings in times of scarcity but also for the creation of institutional preconditions for long-term resilience – that is, the ability of the state and society to respond rapidly to challenges, minimize the consequences of shocks, and at the same time use crises as a driver for structural transformations.

The relevance of studying the integration of circular economy principles into state anti-crisis models is reinforced by the fact that they have become part of major contemporary policy initiatives, such as the European Green Deal and the Ukraine Facility program, both aimed at

recovery and modernization. These initiatives lay the groundwork for the use of circular mechanisms as tools of economic stabilization and recovery.

Thus, the circular economy can be considered not only as an environmental or resource-based approach but also as a systemic instrument for designing new economic models that strengthen state resilience during crises and

create the foundation for long-term economic security and innovative growth.

The logical next step is to demonstrate how circular economy principles – particularly the 10R model – can be integrated into the system of state anti-crisis regulation in the context of ensuring economic security (Table 1).

Table 1

Integration of the 10R Principles into the System of State Anti-Crisis Regulation in the Context of Economic Security

Component of Economic Security	Integrated 10R Principles	Significance in the Context of Anti-Crisis Regulation
Macroeconomic	Refuse (abandonment) of environmentally hazardous industries; Rethink (reconsideration) of consumption models; Reduce (reduction) of resource use in the public sector	Reducing budget expenditures on eliminating the consequences of crises, and shaping resource-efficient state policy
Financial	Reuse of financial instruments; Repair of banking mechanisms; Refurbish of insurance models	Strengthening financial resilience, ensuring access to liquidity under crisis conditions
External economic	Remanufacture for exports; Repurpose (repurposing) of production under external demand	Diversification of foreign trade, reducing dependence on imports of critical resources
Production	Recycle of production waste; Recover (energy recovery) in industrial cycles	Reducing production costs, strengthening the resilience of industries in crisis conditions
Investment and innovation	Redesign of products and processes; Refurbish of technologies	Stimulating innovation and enhancing efficiency during a crisis period
Social	Rethink employment models; Reuse of skills through retraining	Ensuring employment, adapting the labor market to crisis shocks
Food	Reduce food waste; Reuse of production leftovers	Guaranteeing food security and reducing the risk of shortages during a crisis

Source: developed by the author.

The integration of circular economy principles under the 10R model into the system of state anti-crisis regulation significantly expands the potential of traditional economic security instruments. While classical mechanisms are mainly aimed at short-term stabilization and overcoming the consequences of crises, the application of circular economy principles makes it possible to simultaneously ensure resilience and long-term modernization of the economy.

At the macroeconomic level, the combination of principles such as Refuse and Rethink promotes the abandonment of environmentally and resource-inefficient practices and the formation of new models of consumption and public spending, thereby reducing the fiscal burden during a crisis. In the financial sphere, the principles of Reuse and Refurbish transform banking and insurance instruments into more adaptive forms suited to crisis conditions, ensuring the availability of liquidity and financial services.

For external economic security, the integration of Remanufacture and Repurpose principles enables diversification of exports and reduces dependence on imports of critical resources, thus strengthening economic autonomy. In the production sector, the principles of Recycle and Recover increase resource efficiency and minimize losses during crises, while in the field of innovation and investment, Redesign and Refurbish create the foundation for structural renewal of the economy even in times of instability.

Social and food security, in turn, benefit from the principles of Rethink, Reuse, and Reduce, which support labor market adaptation, enhance labor mobility, and ensure a basic level of food supply. This forms a basis not only for minimizing risks but also for creating new development opportunities in the recovery phase.

Thus, the application of circular economy principles in state anti-crisis regulation transforms it from a "firefighting" mechanism into an instrument of comprehensive transformation that simultaneously addresses current problems and sets the course for long-term resilience and innovative development.

The next step of the research is to clarify how circular economy principles are integrated into the system of state anti-crisis regulation at the institutional level. This is particularly important since institutional mechanisms determine the effectiveness of policy implementation, their alignment with international commitments, and their ability to ensure economic security in crisis conditions. The experience of the European Union, which has embedded the normative foundations of the circular economy within the framework of the European Green Deal, and of Ukraine, which is implementing relevant reforms under the Ukraine Facility in crisis conditions, makes it possible to trace the interrelation between European and national strategic approaches and to assess their potential for shaping a sustainable model of economic recovery (Table 2).

The integration of circular economy principles within the framework of the European Green Deal and the Ukraine Facility reflects the consistent transfer of European practices into the national context through their consolidation in the format of specific reforms. The EU sets the strategic benchmarks – industrial mobilization, eco-design, the right to repair, waste reduction in critical sectors, enhanced transparency of ESG reporting, and process digitalization – while Ukraine ensures the implementation of these approaches through a comprehensive set of measures in climate policy, industrial emissions regulation, waste management, reporting development in the extractive sector, and digital transformation.

The synergy of these two strategic frameworks generates a range of positive effects: reducing the energy intensity of production, diversifying foreign economic relations, strengthening industrial resource efficiency, developing repair and service industries, and establishing an institutional foundation for transparent and controlled post-war reconstruction. Importantly, this approach not only reflects the adaptation of Ukrainian reforms to European standards but also creates new opportunities for integration into the EU internal market, which is directly linked to the country's long-term economic resilience and innovative development.

Table 2

**Integration of Circular Economy Principles in the European Green Deal and the Ukraine Facility:
Implications for Economic Resilience and Post-War Recovery of Ukraine**

European Green Deal	Ukraine Facility (European Parliament, 2024)	Circular Economy Principles (EU)	Significance of Implementation for Ukraine (Resilience and Recovery)
Mobilization of industry for a climate-neutral economy; Circular Economy Action Plan (2020)	Section 15 "Green Transition". Reforms 2–4: climate policy, carbon pricing, resource protection	Eco-design	Reduction of energy intensity in production, integration into the EU market, creation of "green" jobs
Control of industrial pollution, strict standards for Environmental Impact Assessment (EIA/SEA)	Section 15. Reforms 1 and 6: industrial emissions, regulation of EIA/SEA exemptions	Right to Repair	Extension of product life cycles, development of repair services, and reduction of household and business costs
Focus on energy-intensive sectors: steel, chemicals, cement, textiles, electronics	Section 15. Reform 5: Circular Economy strategy and action plan; National Waste Management Plan	Waste reduction in critical sectors	Decreasing dependence on raw material imports, resource efficiency in industrial reconstruction
Consumer policy: durable and repairable products; reliable information (ESG transparency)	Section 13. Management of critical raw materials. Reform 3: ESG reporting in the extractive sector	Principles of sustainable consumption and ESG disclosure	Harmonization with European standards, prevention of "greenwashing", integration into global value chains
Digitalization as a driver of the circular economy: digital product passports	Section 14. Digital transformation	Digital CE	Building digital infrastructure for resource management, accelerating recovery through transparency and control

Source: European Commission (2019; 2020).

The analysis has demonstrated that the integration of circular economy principles into the system of state anti-crisis regulation creates opportunities for the profound transformation of institutional mechanisms for ensuring economic security. The evolution of circular economy principles – from the basic 3R model to the modern 10R paradigm and the EU's political frameworks – illustrates the expansion of instruments capable of simultaneously reducing crisis-related risks and fostering long-term resilience. The synchronization of these principles with the institutional instruments of macroeconomic, financial, production, investment-innovation, social, and food security establishes the foundations for the comprehensive modernization of state anti-crisis policy. The experience of the European Union and Ukraine's Recovery Plan (Ukraine Facility) demonstrates that combining circular approaches with anti-crisis instruments not only enhances the economy's adaptability to shocks but also sets the trajectory for sustainable growth and integration into the European economic space.

At the same time, the institutional level reflects only the potential framework for integrating circular economy principles. To assess their practical effectiveness, it is necessary to turn to the empirical analysis of the activities of economic agents at the micro level in ensuring economic security and resilience.

Empirical Assessment of Ukrainian Enterprises in Ensuring Economic Security and Sustainability. In scientific research, economic resilience – both at the state (macroeconomic) level and at the level of individual enterprises (microeconomic) – is generally understood as the ability to adapt and continue development after internal and external shocks. The foundations of scholarly approaches to resilience analysis are rooted in the works of Rose and Krausmann (2013), who defined resilience as the capacity of a system to maintain functioning during shocks (static resilience) and to accelerate recovery after shocks (dynamic resilience). Scholars largely interpret resilience as the inherent capacity of an economic system (at either macro- or micro-levels) to adjust and recover following the impact of various disruptions. There is also an alternative perspective that views resilience not as a property of the system but as a potential that must be developed. This

approach highlights the importance of fostering the potential for "response, monitoring, learning, and anticipation," particularly in the context of long-term crises such as climate change or war.

At the beginning of the full-scale war, as noted by Bohomaz (2025), the value profile of enterprises began to play an even more significant role for stakeholders. According to Bohomaz, particular importance is now attached to the element of business support for the state during this difficult period and to the absence of active ties with the aggressor country. Numerous studies of Ukrainian business practices indicate that in corporate sustainability policies, the social dimension has come to the forefront – support for employees, vulnerable groups of the population, the state, and the Armed Forces of Ukraine. For example, according to a study conducted by CSR Ukraine and *The Page*, in the period from February 24, 2022, to December 31, 2022, the majority of Ukrainian businesses concentrated their efforts on ensuring employee safety, supporting the combat capability of the Armed Forces of Ukraine, and assisting local communities (CSR Ukraine) (Fig. 2).

According to the 2024 study on the resilience of Ukrainian business, almost 100% of respondents emphasized that their role as businesses was to support the state through tax payments and to strengthen the Armed Forces of Ukraine in this war through corporate social and charitable activities directed toward supporting the military and employees currently defending the country on the front lines (One Philosophy). Furthermore, according to a study on the state and needs of business conducted by the Center for Innovation Development, the Office for Entrepreneurship and Export Development, and the national project Diia.Business, and AdvanterGroup in November–December 2024, 70.4% of companies reported providing assistance to the Armed Forces of Ukraine, allocating on average 1.9% of their turnover for this purpose (Center for Innovation Development, 2024). The study also revealed that half of the enterprises (50.4%) assisted employees and their families, nearly one-third (29.6%) to internally displaced persons, 17.2% participated in social initiatives, and almost one in ten enterprises contributed to community recovery (Center for Innovation Development, 2024).

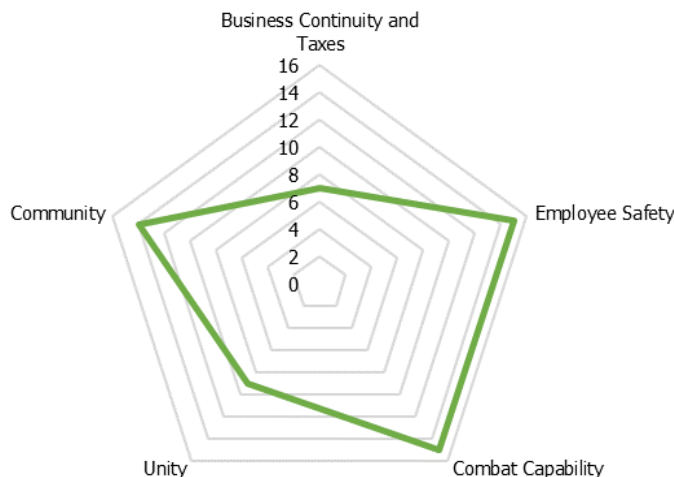


Fig. 2. The most widespread practices of Ukrainian business in 2022

Source: Center for Innovation Development (2024).

One of the main challenges faced by Ukrainian businesses during the war, which directly affects enterprise resilience, is the shortage of qualified personnel. According to the 2024 business resilience survey, 80% of respondents reported experiencing a lack of human resources (One philosophy, 2024). Furthermore, a study conducted by the Institute for Economic Research (IER) in February 2025 found that for 63 enterprises, labor shortages had become the most acute obstacle to business development.

The shortage of skilled personnel is linked to significant migration processes caused by the full-scale invasion and active hostilities, mobilization, and the loss of both military and civilian lives. Experts emphasize that this shortage may negatively affect post-war recovery, as the share of migrants planning to return to Ukraine after the war is decreasing annually. Most enterprises, recognizing the importance of qualified personnel for business resilience, are developing strategies for employee recruitment and retention. According to the 2025 resilience survey, such strategies include: ensuring competitive wages and social benefit packages; training women for professions historically dominated by men; creating internal corporate career pathways; involving staff in corporate volunteering and social projects; digitalization and optimization of internal processes; employee upskilling and reskilling programs; strategic efforts to prepare future personnel; and fostering intergenerational collaboration (One philosophy, 2024).

The shortage of qualified personnel has become not only the main obstacle to the development and resilience of Ukrainian companies but also a threat to the resilience of the economy as a whole. Among the most likely threats to economic security in terms of both impact and probability of occurrence in 2026–2028, the report *"Economic Security of Ukraine under High War Risks and Global Instability"* by the Center for Economic and Social Research of the National Institute for Strategic Studies identified: a shortage of skilled labor (a reduction in labor potential due to intensive migration abroad, a significant share of internally displaced persons, civilian losses caused by hostilities, and a deepening labor deficit in agricultural production); a substantial deterioration in the socio-economic situation of vulnerable groups of the population; severe environmental degradation (including war-related pollution) caused by military actions; and underfunding of certain budget expenditures due to the state's limited financial capacity (Zhalilo, 2025).

Based on these threats and the components of resilience of Ukrainian enterprises and organizations, the key components of corporate sustainable development that have a direct impact on the economic security and resilience of the state were identified (see Table 3).

These components of sustainable development formed the basis for examining the impact of Ukrainian enterprises on ensuring the country's economic security and resilience during the full-scale war. Using the proposed components of sustainable development, the activities of 22 enterprises from six sectors (agriculture, retail, energy, IT, metallurgy, and telecommunications) were analyzed. These companies were selected from the *Top 200 Largest Private Companies in Ukraine by Turnover in 2023*, ranking published by *Forbes*. For each selected sector, up to five enterprises from the first 100 companies on the list were chosen for analysis. The study reviewed sustainable development practices for which information was publicly available – in sustainability reports, on company websites, or in interviews of company representatives with business media. The enterprises analyzed included: Kernel, MHP, Eridon, Ukrlandfarming, Astarta, ATB, Fozzy Group, Epicenter K, Rozetka, Comfy, DTEK, SoftServe (SoftServe, 2024), EPAM Ukraine, Genesis, GlobalLogic, Metinvest, ArcelorMittal Kryvyi Rih, Interpipe, Nikopol Ferroalloy Plant, Kyivstar, Vodafone, and Lifecell.

The analysis of sustainable development practices demonstrated that the most widespread initiatives are those aimed at supporting society and employees. Environmental protection practices, meanwhile, were implemented by just over half of the enterprises during the war (Fig. 3).

Among the practices of supporting society and employees, the most widespread are assistance to the Armed Forces of Ukraine (AFU), community support and development, employee upskilling and reskilling programs, employee support programs, and employee safety programs (Table 4). All enterprises provide financial and material assistance to the AFU. For example, Metinvest established the production of special steel for armor plates used to manufacture bulletproof vests and shields for equipment protection, as well as materials and equipment for the construction of fortifications and trenches. A large quantity of equipment and gear was also purchased and delivered to defenders, including drones, thermal imagers, communication devices, backup power systems, and various types of transport (Metinvest, 2023).

Table 3

**Components of Corporate Sustainable Development and Their Impact
on the Challenges and Threats to Ukraine's Economic Security**

№	Components	Elements of Sustainable Development	Challenges and Threats to Ukraine's Economic Security
1	Employee safety (relocation programs, shelters, flexible work schedules)	Social. Employee support and development	Shortage of qualified labor
2	Employee support (psychological support programs, financial assistance, health insurance programs, additional leave [childcare], support for mobilized employees)	Social. Employee support and development	Shortage of qualified labor
3	Inclusion of women, internally displaced persons (IDPs), people with disabilities, and veterans in company employment	Social. Employee support and development	Shortage of qualified labor
	Employee training and retraining	Social. Employee support and development	Shortage of qualified labor
4	Volunteering programs	Social. Employee support and development	Underfunding of certain budget expenditures due to the state's limited financial capacity
5	Career guidance programs for youth and cooperation with higher education institutions	Social. Employee support and development	Shortage of qualified labor
6	Community support and development	Social. Community support and development	Substantial deterioration of the socio-economic situation of vulnerable population groups
7	Support for internally displaced persons (IDPs)	Social. Community support and development	Substantial deterioration of the socio-economic situation of vulnerable population groups
8	Support for the Armed Forces of Ukraine (AFU)	Social. Community support and development	Underfunding of certain budget expenditures due to the state's limited financial capacity
9	Assistance to the government and municipalities	Social. Community support and development	Underfunding of certain budget expenditures due to the state's limited financial capacity
10	Resource conservation	Environmental	Significant environmental degradation caused by hostilities
11	Waste management	Environmental	Significant environmental degradation caused by hostilities
12	Reduction of CO ₂ emissions	Environmental	Significant environmental degradation caused by hostilities
13	Environmental modernization of production facilities	Environmental	Significant environmental degradation caused by hostilities
14	Biodiversity protection	Environmental	Significant environmental degradation caused by hostilities

Source: developed by the author.

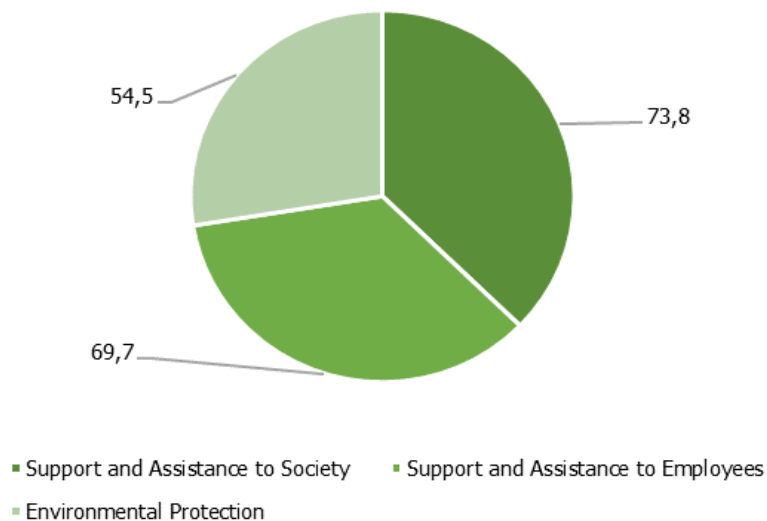


Fig. 3. The most widespread practices of Ukrainian business in 2024

Source: developed by the author based on the data of the analyzed enterprises.

Table 4

Dissemination of Sustainable Development Practices among Ukrainian Enterprises during the Full-Scale War with Russia

Components	Elements of Sustainable Development	Share of Enterprises Implementing, %
Employee safety (relocation programs, shelters, flexible work schedules)	Social. Employee support and development	72.7
Employee support (psychological support programs, financial assistance, health insurance programs, support for mobilized employees)	Social. Employee support and development	81.8
Inclusion of women, internally displaced persons (IDPs), people with disabilities, and veterans in company employment	Social. Employee support and development	63.6
Employee training and retraining	Social. Employee support and development	86.4
Volunteering programs	Social. Employee support and development	63.6
Career guidance programs for youth and cooperation with higher education institutions	Social. Employee support and development	50.0
Community support and development	Social. Community support and development	95.5
Support for internally displaced persons (IDPs)	Social. Community support and development	54.5
Support for the Armed Forces of Ukraine (AFU)	Social. Community support and development	100.0
Assistance to the government and municipalities	Social. Community support and development	45.4
Resource conservation	Environmental	63.6
Waste management	Environmental	68.1
Reduction of CO ₂ emissions	Environmental	40.9
Environmental modernization of production facilities	Environmental	59.0
Biodiversity protection	Environmental	40.9

Source: developed by the author based on the data of the analyzed enterprises.

Among corporate practices of assisting communities and the state, the most widespread are material support for hospitals, assistance to communities in accommodating internally displaced persons, implementation of pro bono projects, and the provision of equipment and other resources. For example, DTEK (DTEK, n. d.) provided free electricity to the military, hospitals, and critical infrastructure facilities in Kyiv, Dnipropetrovsk, and Donetsk regions (more than 100 infrastructure facilities). SoftServe, within the framework of the global EmpowerU program (SoftServe, 2024), offers free IT courses through the SoftServe Academy, providing career development opportunities for newcomers to the IT sector – primarily for people from vulnerable groups, including women, persons with disabilities, veterans, refugees, and others. Additionally, EPAM volunteers (EPAM, 2023), at the request of the Ministry of Foreign Affairs of Ukraine, developed and implemented substantial improvements to the *E-Queue* electronic system, which ensures online booking for Ukrainian consulates and prevents fraud.

Corporate programs for employee support and development are aimed at creating safe working conditions. These include relocation programs launched in 2022 (for example, ArcelorMittal Kryvyi Rih temporarily evacuated 1,000 family members of employees to Western Ukraine and Poland (Yermolenko, 2024); MHP [Myronivsky Hliboproduct] evacuated 600 employees and their families from Irpin, Bucha, and Hostomel, as well as partially relocated employees to Western Ukraine), programs supporting mobilized employees, and psychological assistance initiatives (for instance, MHP operates "Resilience School 3.0") (Forbes Ukraine, 2022).

In recent years, companies have also actively introduced programs for the employment and support of women in traditionally male professions (ArcelorMittal Kryvyi Rih); employment and support of veterans (programs covering physical and psychological rehabilitation, retraining, and individual adaptation initiatives are in place at Interpipe, Vodafone Ukraine, Kernel, and others); and hiring of employees aged 60+ (for example, Astarta has increased the share of employees aged 60+ by 5% and is implementing the project "Active and Healthy Longevity" (Astarta, 2024).

The analysis of Ukrainian enterprises' practices in the field of employee engagement and support during the war

made it possible to develop sustainability indicators (component – employee engagement and support) that demonstrate business contributions to the country's economic security and resilience during wartime. These include the share of preserved or newly created jobs, the share of hired internally displaced persons (IDPs) and veterans, the share of employees covered by psychological support programs, the share of employees who completed upskilling and reskilling programs, the number of shelter places, and the share of employees who completed training in first aid and emergency response.

Regarding the environmental practices of Ukrainian enterprises, only about half have implemented environmental protection programs, many of which were deprioritized at the onset of the war. However, their renewal and active implementation may begin in the near future. The driving force behind this process will be the implementation of the Ukraine Recovery Plan, which is synchronized with the European Green Deal and sets a target of reducing CO₂ emissions by 65% by 2032 compared to 1990 levels. This implies that enterprises must adapt their business models to the requirements of the European Green Deal, including the complete phase-out of coal in energy production; shifting freight transport from road to rail and waterways; developing renewable energy sources; reusing materials; and designing products for long-term use (e.g., electronics) with the potential for repair and recycling.

Discussion and conclusions

The conducted study not only makes it possible to record the transformation of economic models and corporate strategies under polycrisis conditions but also to formulate sustainability indicators that can serve as a tool for assessing business contributions to strengthening national resilience.

The obtained results are consistent with existing scholarly contributions in the field of economic resilience (Rose, 2007; Martin, & Sunley, 2020; Malik, Szewczuk-Stępień, & Bębenek, 2025), yet this study goes a step further by applying a comprehensive methodology for assessing sustainable development practices at the level of Ukrainian enterprises during wartime. Thus, the research expands the scope of previous studies, which largely focused on the macroeconomic level, and demonstrates the practical dimension of the interrelation between corporate sustainability practices and national economic security.

Importantly, the analysis made it possible to test and confirm the scientific hypothesis of the study: the spread of sustainable and resilient development practices among Ukrainian enterprises directly contributes to strengthening the state's economic security, enhances its ability to withstand military and global risks, and provides the foundation for post-war recovery. Empirical findings indicate that the most critical aspects for economic resilience are the social dimensions of sustainable development – employee support, job retention, community development, and assistance to the Armed Forces of Ukraine. These function as "core practices" that preserve the integrity of the economic system in conditions of prolonged crisis.

The consistency of the findings with current EU approaches regarding the integration of circular economy principles and ESG reporting into public policy and corporate practices confirms that the chosen research trajectory is not only relevant but also strategically important for post-crisis and post-war recovery. Thus, the results of this work not only systematize theoretical models but also prove their effectiveness through the case of Ukrainian enterprises under crisis conditions, thereby addressing the stated research objective and providing a basis for the further development of sustainability indicators across all dimensions – social, economic, and environmental.

The research on the integration of circular economy and resilience principles into state anti-crisis policy confirmed their key role in transforming institutional mechanisms for ensuring economic security. The use of the 10R model enables the transformation of anti-crisis regulation from a tool of short-term stabilization into a means of profound economic modernization. The case of Ukraine, which is implementing relevant reforms within the Ukraine Facility and aligning them with the European Green Deal, demonstrates the feasibility of this approach.

The empirical analysis of Ukrainian enterprises during the full-scale war revealed that business demonstrates high adaptability and develop sustainable strategies even under crisis conditions. The most widespread practices were socially oriented – employee support, community assistance, and contributions to strengthening the combat capability of the Armed Forces of Ukraine. Environmental aspects of sustainable development have remained less prioritized, but their significance is expected to increase in the process of post-war recovery and adaptation to the requirements of the European Green Deal.

Of particular importance is the identification of key components of corporate sustainable development that directly affect the economic security and resilience of the state. These include measures to preserve and develop human resources, social support for vulnerable groups, and corporate engagement in meeting the critical needs of society and the military. At the same time, ecological modernization of production capacities and the introduction of circular practices create an additional reserve for strengthening the resilience of the national economy.

Based on the conducted analysis, sustainability indicators (component – employee engagement and support) were developed, allowing for the quantitative assessment of business contributions to economic security and resilience under wartime conditions. Their application will support the creation of a monitoring system for enterprise resilience and enable the integration of corporate efforts into nationwide recovery and development strategies.

Thus, the results of the study confirmed the scientific hypothesis formulated in the introduction: the spread of sustainable and resilient development practices among Ukrainian enterprises directly contributes to strengthening the economic security of the state, enhances its ability to

withstand military and global risks, and lays the foundation for inclusive and sustainable post-crisis recovery.

The prospects for further research involve an in-depth analysis of sustainability indicators based on an expanded sample of enterprises and consideration of sectoral specificities, as well as the development of integrated methodologies for assessing economic resilience in wartime and post-war periods. Particularly relevant is the study of opportunities for the systemic integration of circular economy principles into state anti-crisis policy, fiscal and tax mechanisms, and corporate strategies. Future research should also combine macroeconomic and microeconomic levels of analysis, develop scenarios for digital support of circular practices, and adapt European sustainability standards to Ukrainian conditions. This will contribute to establishing a methodological foundation for modernizing economic policy and enhancing Ukraine's economic security under polycrisis conditions.

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ІНТЕГРАЦІЯ ПРИНЦИПІВ ЦИРКУЛЯРНОЇ ЕКОНОМІКИ Й РЕЗИЛІЄНТНОСТІ У ДЕРЖАВНУ АНТИКРИЗОВУ ПОЛІТИКУ ТА КОРПОРАТИВНІ СТРАТЕГІЇ

Вступ. Сучасні глобальні виклики – від кліматичних змін до воєнних конфліктів – полягають в актуалізації пошуку нових економічних моделей, здатних поєднувати завдання сталого розвитку та підвищення резилієнтності суспільств і економік. Метою дослідження є систематизація теоретичних підходів до формування нових економічних моделей сталого розвитку та резилієнтності, визначення їхнього потенціалу для зміцнення економічної безпеки держави і підприємств, а також обґрунтування можливостей інтеграції принципів циркулярної економіки та резилієнтності у державну антикризову політику й корпоративні стратегії на прикладі України. У центрі наукової гіпотези роботи – припущення, що поширення практик сталого резилієнтного розвитку серед українських підприємств безпосередньо впливає на економічну безпеку держави, формуючи її здатність протистояти воєнним і глобальним ризикам.

Методи. Методи аналізу та синтезу, узагальнення; метод структурно-функціонального аналізу; графічний і табличний методи.

Результати. У процесі дослідження проведено типологізацію нових економічних моделей (зеленої, циркулярної, ощадливої, солідарної, креативної тощо), проаналізовано їхній потенціал у забезпеченні стійкості й економічного відновлення після криз. Особливу увагу приділено еволюції принципів циркулярної економіки (від 3R до 10R), що розглядаються як інституційна основа для посилення антикризового регулювання та довгострокової економічної безпеки. Емпіричний блок дослідження побудовано на аналізі практик сталого розвитку 22 найбільших українських підприємств із шести галузей, які демонструють високу адаптивність у період війни. Серед поширених практик – підтримка співробітників, громад, допомога Збройним силам України, а також екологічна модернізація виробництва. На цій основі виокремлено ключові компоненти сталого розвитку, що безпосередньо впливають на економічну безпеку держави, та запропоновано індикатори оцінювання внеску бізнесу у забезпечення стійкості.

Висновки. Результати підтвердили наукову гіпотезу: практики сталого розвитку в умовах війни зміцнюють економічну безпеку держави та формують основу для інклюзивного післякризового відновлення. Робота поєднує систематизацію теоретичних моделей із прикладним аналізом корпоративних стратегій, що забезпечує її наукову новизну та практичну значущість. Перспективи подальших досліджень пов'язано з розробленням інтегральних методик оцінювання стійкості економіки, цифровою підтримкою циркулярних практик і гармонізацією українських стандартів сталого розвитку з європейськими.

Ключові слова: циркулярна економіка, економічна безпека, резилієнтність, нормативно-правове забезпечення, повсюдне відновлення, соціальна відповідальність, фінансове регулювання, макроекономічна стабільність.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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MEZZANINE FINANCING OF UKRAINE'S ENERGY INFRASTRUCTURE IN THE POST-WAR RENEWAL

Background. *The Government of Ukraine has developed the Energy Strategy up to 2050, which aims to strengthen energy security and resilience and introduces targets for energy efficiency, environmental safety, reducing carbon emissions, etc. Post-war recovery combined with simultaneous modernization of Ukraine's energy sector will require the mobilization of significant financial resources, highlighting the importance of examining advanced global experience in attracting investment to energy infrastructure. The aim of the article is to substantiate promising methods of financing energy facilities for their implementation and application in the Ukrainian economy during the post-war renewal period.*

Methods. *Employed in the study include factual and situational analysis, synthesis, deduction, systems approach method, and theoretical generalization.*

Results. *The article analyzes global experience in applying and combining methods of financing energy infrastructure. It formulates the key principles for mobilizing investment in modern energy. The study provides analytical conclusions with justifications regarding the prospects and relevance of implementing and applying mezzanine financing for the post-war renewal of Ukraine's energy sector. The most priority and optimal mezzanine forms of attracting investments to the energy sector are identified.*

Conclusions. *The study distinguishes the key principles for mobilizing investment in the energy sector, namely: consideration of energy security and socio-economic stability aspects, mobilization of non-state financing, minimization of the cost of capital, harmonization of the project's cash flows, fair risks and returns allocation. Based on global experience, a comparison of primary capital mobilization methods for energy infrastructure (from the state/IFIs, equity, debt, mezzanine) is performed. The prospects and relevance of mezzanine financing for implementation and application in the Ukrainian economy are substantiated. The most optimal forms of mezzanine financing for the energy sector are identified as securitization with tranching and subordinated debt financing. It is determined that Ukraine's institutional framework for these capital raising instruments has the potential for improvement and represents a promising direction for further researches. The study recommends the prompt implementation and institutionalization of mezzanine financing in the Ukrainian economy.*

Keywords: *mezzanine financing; energy infrastructure financing; forms of mezzanine financing; post-war recovery of Ukraine's energy sector; securitization with tranching; subordinated debt.*

Background

The energy sector constitutes the most important part of critical infrastructure, since energy functions as a primary resource for all industry branches, transport, telecommunications, and the service sector, while the availability of a stable energy supply is a prerequisite for ensuring the basic sanitary and household needs of the population. Consequently, the systematic destruction of energy generating and distribution facilities due to military actions poses not only a short-term threat but also a long-term negative strategic impact on Ukraine's recovery and sustainable development, thereby necessitating urgent and comprehensive restoration of energy facilities.

In response to the challenges, the Government of Ukraine has developed the Energy Strategy to 2050 (Ministry of Energy of Ukraine, 2023) (the full text is temporarily unavailable in open access). The Strategy considers the consequences of a full-scale war and envisages a strengthened role for energy security and decentralization to enhance the resilience of the energy system. It also foresees the introduction of advanced technologies (such as the use of hydrogen in energy, small modular nuclear reactors, etc.) and sets the requirements for energy efficiency, environmental safety, and reduction of carbon emissions in accordance with EU regulations and Ukraine's international obligations. The Strategy aims to achieve its objectives through the development of nuclear generation, renewable energy sources, modernization, and automation. Undoubtedly, along

with setting strategic guidelines and current objectives, there arises a need to mobilize financial resources for their implementation. At the same time, the global level of recognition and implementation of the Sustainable Development Goals (SDGs) and ESG criteria is growing: investors are increasingly and more strictly adhering to the principle that financial results should be achieved with minimal negative impact. Consequently, energy sector post-war reconstruction and development will only take place in light of, and with due regard to, the SDGs and ESG principles, which, in turn, will necessitate the attraction of additional financing. Moreover, the challenge of securing investment is deepened by global political and economic instability and uncertainty, as well as by Ukraine's historically high country risk premium, which is now approximately 17% (Naumenkova, Mishchenko, & Tishchenko, 2024) due to the ongoing war.

Ukraine traditionally operates under a banking model of financial intermediation. However, as of September 1, 2025, the portfolio of loans issued by the banking system to business entities amounts to about USD 22 billion (Total assets of banks in Ukraine (2008–2025), 2025), which is insufficient compared to the overall forecast investment needs of the economy, estimated at USD 750 billion (Ministry of Economy of Ukraine, 2023). Additionally, to ensure financial stability, the banking system must comply with regulatory requirements regarding capital adequacy, liquidity, loan loss provisions, risk concentrations, and other prudential limits. These factors indicate the inherent

limitations of relying solely on traditional bank lending to finance large-scale infrastructure projects, in particular the energy sector.

Therefore, the study and analysis of global experience in attracting investment into energy infrastructure, particularly with respect to legal structuring and financing mobilization mechanisms, have become increasingly relevant for determining promising energy financing practices suitable for subsequent implementation in the Ukrainian economy.

One of the widely used methods of attracting investment in energy facilities in the world is mezzanine financing, the forms of which simultaneously have the features of debt and equity financing. Mezzanine forms of raising capital meet the needs of energy facilities for flexible long-term financing and hence may serve as a strategic mechanism for the recovery and development of Ukraine's energy infrastructure.

The paper aims to examine advanced global experience in energy infrastructure financing and to justify promising forms of capital mobilization that are relevant for implementation and application in the Ukrainian economy in the post-war renewal period.

Hypothesis: Implementing and applying mezzanine financing mechanism will positively contribute to the successful post-war recovery and development of Ukraine's energy infrastructure.

Literature review. The body of research on strategies, methods, and instruments for mobilizing investment in energy or capital-intensive long-term infrastructure projects – including the energy sector – is largely comprised of specialized fundamental studies by researchers, in particular Weber, B., Staub-Bisang, M., Alfen, H., Halbout, J., Riboud-Seydoux, M.-N., and Nijs, L.; numerous publications by the OECD; analytical reports by consulting companies, in particular Deloitte; and publications by other authors that provide in-depth analysis of specific aspects of the issue. These sources examine the current state of infrastructure financing in developed and developing countries, highlighting issues related to access to finance, investment sources, risk factors, and risk allocation among stakeholders.

Generally, the literature distinguishes the following primary financing methods: 1) State/IFIs financing in the context of leveraging and unlocking private commercial investment, 2) Equity financing, 3) Debt financing, and 4) Mezzanine financing. Energy investments are considered solely within the scope of clean energy (including nuclear, which has been classified as part of the EU Taxonomy since 2023 (European Commission, 2022) and alignment with sustainable development goals and ESG principles.

Weber, Staub-Bisang, and Alfen (2016) in their foundational work, comprehensively analyze infrastructure investment trends in light of Sustainable Development Goals. Infrastructure is conceptualized as a distinct asset class, with investment risks categorized by the authors into 1) general risks (market, ESG, political and regulatory, etc.), 2) project- or asset-specific risks (construction, technical, financial, etc.), and 3) industry-specific risks. The authors provide detailed descriptions of core infrastructure sectors, including energy, highlighting technical and regulatory aspects. Substantial attention is paid to PPP as a vehicle of project finance (outlining its characteristics, principal stakeholders with their objectives and contributions, finance structuring, etc.). The primary methods of infrastructure financing identified are equity, debt, mezzanine financing, state/IFIs financing, and others.

Halbout and Riboud-Seydoux (2022) examine the financing of energy projects, focusing on various methods of capital raising and financial instruments. They emphasize

that no standardized approach applies, given the diverse geographical, technological, and technical contexts of the projects. The primary methods of capital raising identified are equity, debt, and mezzanine (hybrid) financing. Particular attention is drawn to mezzanine financing due to its flexibility, lower cost compared to equity capital, and reduced pressure on the project's cash flows. The authors identify project finance and corporate finance as the predominant financing models. The study further maps the most relevant capital providers and methods of finance mobilization across different stages of the energy project lifecycle (Exploration and Appraisal, Development and Production, Decommissioning).

Nijs (2014) in his comprehensive book, distinguishes between corporate and project finance of large infrastructure projects, which include energy in particular, and analyzes the respective advantages and drawbacks of each investment structuring approach. The author notes that capital is raised predominantly through debt instruments (70-80%), in contrast, employing equity financing beyond 20%-30% typically renders the project unattractive for capital providers, given the availability of more favorable alternatives. It is concluded that accurate risk identification and optimal risk allocation (each specific risk should be allocated to the party most capable of managing it at the lowest cost) contribute to reducing the project's weighted average cost of capital. It is further observed that projects with substantial capital requirements are typically resorted to using financing or guarantees (financial or non-financial) from sponsors, as well as mezzanine finance instruments. The book also examines the securitization of project finance loans, particularly through mezzanine and junior tranches, which carry higher risk exposure for investors compared with senior debt.

The OECD Policy Guidance (2015) analyzes financial markets in the context of investments in clean energy infrastructure, examines the barriers to accessing finance and sources of capital, and proposes measures to improve access to funding. Suggested instruments include partial credit guarantees, financing from IFIs, development of domestic financial markets and accessible financial instruments, and mobilization of institutional investors through a favorable regulatory environment. In the Study, the OECD (2018) further recommends that governments stimulate investment in low-carbon infrastructure by initiating the creation of public-private partnerships; deploying guarantees to reduce, mitigate, or reallocate investment risks among stakeholders; fostering the development of innovative financial instruments and the standardization of contracts, methods, and processes to reduce administrative and transaction costs and encourage securitization. The Guidance (2022a) notes that the clean energy sector in developing countries receives a significant share of its funding from donor contributions, however, the overall level of mobilized financial resources remains insufficient, leading to calls for a transition from traditional aid to blended finance. Blended finance is defined as a strategic combination of development finance (funds with a development mandate only) together with non-development finance (additional capital provided on commercial terms without an explicit development objective) aimed at supporting sustainable development in emerging economies. Thus, the use of blended finance is expected to amplify the impact of limited donor resources by redirecting funds into new projects as soon as existing investments become commercially viable. Complementary OECD Researches (2022b, 2024) examine and analyze country-

level experiences in financing energy infrastructure, specifically in India and the Philippines. Both publications underscore the positive role of blended finance application, particularly where development finance was deployed to reduce investment risks (i.e., first-loss or non-payment guarantees) for investors, thereby leveraging additional commercial capital. In Publication (2024), the Nuclear Energy Agency (NEA) analyzes the sensitivity of the cost of electricity generated by nuclear power plants to the cost of capital employed, using as case studies recently commissioned nuclear power plants as well as facilities planned for commissioning. The study identifies principal providers of equity (host country governments, equipment suppliers, energy companies (or combinations thereof) and debt financing (supplier country governments, host country governments, commercial banks, institutional investors). The analysis concludes reducing the cost of raising capital through de-risking construction, whereby electricity consumers and taxpayers (i.e., states) absorb these risks, as they are deemed best suited to bear low-probability but high-impact risks.

Deloitte (2023) examines the economic attractiveness of investment in clean energy, particularly in developing countries. It recommends governments to work towards developing financial mechanisms and methods capable of unlocking private capital while maintaining financing costs at an acceptable level. Recommended instruments identified are guarantee mechanisms, the development of capital markets, and the application of a blended finance approach that can mitigate the risks for commercial investors and mobilize private capital. The study concludes that capital-intensive clean energy projects in developing countries are disproportionately expensive due to the high cost of capital resulting from higher political, regulatory, currency, inflationary, and other risks. Accordingly, policy efforts in emerging economies should focus on project risk mitigation and removing barriers to private capital flows. The paper further highlights the role of the Climate Investment Fund (CIF), which provides resources for blended finance products for developing countries, thereby unlocking and catalyzing further private investment. The instruments employed include concessional senior loans, subordinated loans, and other mezzanine instruments designed to mitigate the default risk on senior debt. A follow-up Research (2024) identifies a range of economic and financial instruments to mitigate investment risks in energy assets: 1) Power purchase agreements - reducing market risks, effectiveness depends on the creditworthiness of the purchaser; 2) Tax incentives – fostering debt financing through enhancing project liquidity, particularly effective in developing countries; 3) Grants and concessional loans – effective in developing countries, but costly for taxpayers; and 4) Debt and equity subordination - reducing the investor's risk through mitigating the risk of default on senior debt and acts as an additional guarantee of returns. From the perspective of governments and donors, the costs incurred when using different instruments vary in nature, and not all transform into direct budget outlays. A distinction is made between hard, or direct, costs (grants), contingent hypothetical (guarantees), and lost future income (tax incentives), the latter does not cause government spending, since taxes could not have been collected in the absence of the project. The choice and combination of instruments depend on the geographical, market, and technological contexts; they should operate together with blended finance. Over time, reliance on these instruments is expected to diminish as projects mature and markets deepen.

Karakosta, Corovessi, and Vryzidis (2025) examine the financing of energy efficiency projects across five countries (Bulgaria, Croatia, Greece, Romania, and Slovenia) and identify the best practices for capital raising, including the application of debt financing from dedicated funds, guarantees, energy service contracts combined with grants, etc. The study assesses financing models, identifies barriers to private investment, and enhances understanding of effective strategies for attracting investment in energy efficiency and renewable energy by strengthening cooperation between public and private sectors. A key conclusion highlights the dependence of the development of sustainable financial instruments on political support and recognition of their importance by all stakeholders. González-Ruiz, Botero-Botero, and Duque-Grisales (2018) propose a framework for financing sustainable infrastructure facilities based on mezzanine financing forms (specifically convertible debt), whereby creditors have the option to convert debt into equity (share in the capital) upon achieving criteria linked to sustainable development goals. This financing approach deepens the nexus between finance and sustainable development and offers additional value for investors increasingly guided by sustainable development goals when choosing investment assets. Rajavuori and Huhta (2020) examine the impact of the US and EU national security investment screening framework on the energy sector. They illustrate how investment screening affects the energy sector and creates new challenges for international energy investment, as modern legislation framework increasingly focuses on critical infrastructure, data processing (including the personal data factor), and emerging new energy technologies. The authors emphasize that strengthening regulation negatively affects overall investment readiness in the energy sector.

It is important to note the existence of scientific publications that focus specifically on financing infrastructure and the energy sector in Ukraine.

Zatonatska et al. (2024) identify the key role of ESG principles in the development of the energy sector and justify the need to integrate these practices into Ukrainian legislation for a positive impact on energy efficiency and further sustainable development. Drawing on the example of the Russian-Ukrainian war, the authors conclude the necessity of a reliable and diversified energy infrastructure to mitigate geopolitical risks; consequently, it is recommended for Ukraine to stimulate investment in renewable energy and align post-war recovery with sustainable development goals. Petlenko (2024) examines the green energy financing in Ukraine in the context of establishing sustainable and resilient infrastructure and strengthening Ukraine's energy security. The study highlights that, despite governmental support, the transition to green energy is constrained by the high capital intensity of green technologies, which are often non-competitive without state subsidies. The author emphasizes the importance of attracting both public and private investment and the need to develop new financing instruments for the Ukrainian economy. Examined green energy financing instruments in Ukraine include government subsidies, private investment, and innovative financial solutions, particularly green credit guarantee schemes (Green Credit Guarantee Corporations, CGCs). The study contributes to a deeper understanding of ways and methods of attracting investment for green energy within the framework of post-war infrastructure recovery. The OECD Study (2020) provides a thorough analysis of infrastructure investment in the Eastern Partnership countries, including Ukraine. The

authors note the multiplicative effect of infrastructure investment and the significant role of the private sector in financing the renewable energy development in Ukraine. They identify the priority of developing domestic private financing, which necessitates establishing infrastructure as a distinct asset class. Investment needs in energy and transport infrastructure are recognized as a priority. To enhance private sector participation, the government is recommended to create a favorable regulatory environment, employ risk mitigation instruments (e.g., guarantees), and focus on a blended finance approach to attract private capital. The OECD Review (2021) analyzes Ukraine's energy investment. It concludes that the country lags behind developed economies in establishing effective modern energy infrastructure, and attracting private investors is one of the necessary steps for the energy sector modernization. The government is advised to develop and improve the mechanisms for facilitating public-private finance. The study highlights that long-term investment in Ukraine's energy infrastructure, which can be attracted from the private sector, is a priority for the country's development. It also identifies the potential for renewable energy expansion (including biomass, wind, and solar). Energy infrastructure projects are noted to require the mobilization of significant financial resources upfront, while generating returns only in the medium- and long-term. Finance resources are constrained by the fact that investors perceive the risks to be too high, which can be partially mitigated through the development of the financial market (depth and liquidity). The OECD identifies foreign and domestic private investors, state-owned enterprises, banks, and international financial institutions as the main providers of investment in Ukraine's energy infrastructure.

Methods

The study utilized **methods** of factual and situational analysis to examine advanced global experience in energy infrastructure financing; synthesis and deduction to formulate the key principles for mobilizing investment in energy infrastructure and to substantiate the high potential and relevance of mezzanine financing for its implementation in Ukraine's economy in the context of post-war recovery; a systems-based approach to justify the impact of mezzanine financing on ensuring the full volume of capital mobilization at an acceptable weighted average cost of capital, and on the allocation of risks and returns among stakeholders; and theoretical generalization to identify the most relevant forms of mezzanine financing for their implementation, institutionalization, and application in Ukraine's economy for financing energy infrastructure.

Results

Energy infrastructure in Ukraine and globally constitutes one of the principal sectors of critical infrastructure (Cabinet of Ministers of Ukraine, 2020; Kudrjashov, 2021; Verkhovna Rada of Ukraine, 2021a). It should be noted that over the past decade, both worldwide and in Ukraine, the development of the environmental component of the energy sector has not only gained significant momentum, but has also become a determining factor influencing attracting investment into energy infrastructure. In 2015, the Paris Agreement (United Nations, 2015) was signed (ratified by Ukraine in 2016), an international treaty aimed at preventing global warming and climate change by reducing greenhouse gas emissions. The international community is committed to significantly reducing carbon emissions in pursuit of climate neutrality.

In 2019, the European Union introduced the European Green Deal (European Commission, 2019), a comprehensive set of policy initiatives through which it aims to achieve carbon

neutrality by 2050. Within the framework of this initiative, mandatory ESG reporting for companies and financial institutions was established, along with the development of the EU Taxonomy – a fundamental document, that clearly defines economic activities aligned with the objectives of achieving net-zero emissions by 2050, thereby attracting investment in relevant sectors of the economy.

In 2022, in the context of the war in Ukraine and the energy crisis in the EU, the role of nuclear and gas energy was reassessed, and through a dedicated Complementary Delegated Act (European Commission, 2022), certain activities in the sector of nuclear and gas energy were, with specific reservations, included in the list of economic activities covered by the EU taxonomy. This change has a positive impact on Ukraine's energy sector, given that a significant share of energy generation in the country relies on nuclear power plants.

In 2023, the Cabinet of Ministers of Ukraine, upon the submission of the Ministry of Energy, approved the Energy Strategy of Ukraine to 2050 (Ministry of Energy of Ukraine, 2023), which sets the objective of achieving net-zero emissions by 2050 and formulates requirements regarding energy efficiency, environmental safety, and carbon emissions reduction in accordance with EU standards and Ukraine's international obligations. The consistency of the Energy Strategy of Ukraine with the European Green Deal is justified (Soboliev, & Zatonatska, 2024), which appears to be a logical consequence of Ukraine's European integration trajectory.

Undoubtedly, the post-war recovery of Ukraine's infrastructure must align with global trends, particularly ensuring strict alignment with the Sustainable Development Goals (SDGs) and ESG criteria; otherwise, the mobilization of private capital is unlikely, and the risks of litigation (Zatonatskiy, & Chernyak, 2023) regarding the non-compliance of energy projects with the country's international obligations arise. Simultaneously, as it was justified (Zatonatska et al., 2024), the integration of ESG principles into the financing of Ukraine's energy infrastructure, along with the harmonization of national policy with European standards, should create the foundation for a reliable and sustainable energy economy and strengthen energy security, which is especially important in the context of geopolitical and military risks in the post-war period.

Based on the critical analysis of the literature (Deloitte, 2023, 2024; González-Ruiz, Botero-Botero, & Duque-Grisales, 2018; Halbout, & Riboud-Seydoux, 2022; Karakosta, Corovessi, & Vryzidis, 2025; NEA, 2024; Nijs, 2014; OECD, 2015, 2018, 2020, 2021, 2022a, 2022b, 2024; Petlenko, 2024; Rajavuori, & Huhta, 2020; Weber et al., 2016; Zatonatska, & Osypenko, 2025; Zatonatska et al., 2024), we formulate the key principles for mobilizing financing in energy infrastructure (beyond the principles of ESG compliance and alignment with the SDGs) as follows:

1. Principle of considering energy security and maintaining socio-economic stability aspects. The state is expected to retain ownership rights and/or exercise additional control over energy facilities, associated technologies and data, given their social function and impact on national security and the economy.

2. Principle of mobilizing non-state financing. The predominant part of investment in the energy sector should be private commercial financing, whereas limited **state/IFIs financing** should be channeled through financial instruments and mechanisms to leverage sufficient volumes of private commercial investments from capital markets.

3. Principle of minimizing the cost of investment capital. The cost of capital raised must be kept to a minimum, since it significantly affects the final cost of generated energy, which in turn directly affects the competitiveness of other sectors of the national economy. For instance, under conditions of a weighted average cost of capital (WACC) of a nuclear power plant at 12% annually, the cost of electricity generation increases by more than 3.4 times compared to interest rates approximating 1% per annum (calculated by the authors based on NEA, 2024).

4. Principle of harmonizing cash flows from financial activities with those from the operational activities of an energy facility (debt maturity and the timing and conditions of interest payments). Capital should be raised in substantial amounts and on a long-term basis, whereas the commencement of interest payments should be aligned with the energy project's cash flows, which are typically absent during the design and construction phases.

5. Principle of a fair and relevant allocation of risks and returns (each specific type of risk should be managed by the

party most competent and best adapted to handle it). Energy projects are subject to additional construction and technical risks, which are further exacerbated in developing countries by political, regulatory, and currency risks. Consequently, the financing structure should ensure a fair balance of risks and returns among stakeholders.

We examine the global experience of financing energy infrastructure. The key investment providers in the energy sector traditionally included: the host-country government of the energy facility, the supplier/constructor country government of the energy facility, the energy company (the owner of the energy facility), the equipment supplier/constructor company, IFIs, commercial banks, and institutional investors. Legally, such investments are typically structured as either corporate finance or project finance, implying the project has a separate balance sheet. Public-private partnerships are classified as a form of project finance. Contemporary global practices are summarized in Table 1.

Table 1

Contemporary Global Practices in Energy Infrastructure Financing

Key Investment Providers	Host country government, energy project supplier/constructor country government, energy facility-owning company, equipment supplier/constructor company, IFIs, commercial banks, and institutional investors			
Legal Investment Structure	Corporate Finance & Project Finance (incl. PPT)			
Financing Mobilization Mechanisms	State and IFIs support*	Equity Financing	Debt Financing	Mezzanine Financing
Financing Forms and Instruments	Power purchase agreements, tax incentives, guarantees, grants, concessional loans under blended finance principles, mezzanine financing instruments (first-loss absorber)	Equity placement, direct investments	Loans, bonds	Mezzanine equity: 1) Silent participation; 2) Preferred shares; Mezzanine debt: 3) Participating loans; 4) Participating bonds; 5) Subordinated loans; 6) Subordinated bonds; 7) Convertible loans; 8) Convertible bonds; 9) Bonds with warrants; 10) Securitization with junior (mezzanine) tranches
Risk Exposure for State/IFIs	Moderate	None	None	None
Financing Cost for Energy Project (Investor's Return)	Low or negligible, reduces WACC	High	Medium	High/Moderate, reduces WACC
Financing Duration	Long/medium	Long	Long/medium	Long/medium
Investment Share (% of Total Project)	≤ 20%, positively leverages debt mobilization	10–30%	60–80%	≤ 20%, positively leverages debt mobilization
Capital Raising Without Control Loss	Yes	No	Yes	Yes
Impact on Balance Sheet Structure/ Creditworthiness/Credit Rating, and Ability to Raise New Debt	Positive	Positive	Negative	Positive
Obligation for Regular Interest Payments	Yes/No	No	Yes	Yes/No
Project Implementation Phases	Exploration and Appraisal, Development and Production, Decommissioning	Exploration and Appraisal, Development and Production, Decommissioning	Development and Production, Decommissioning	Development and Production, Decommissioning

* Cases of direct equity participation or classical debt financing are not considered.

Source: developed by the authors based on Deloitte, 2023, 2024; González-Ruiz, Botero-Botero, & Duque-Grisales, 2018; Halbout, & Riboud-Seydoux, 2022; Karakosta, Corovessi, & Vryzidis, 2025; NEA, 2024; Nijs, 2014; OECD, 2015, 2018, 2020, 2021, 2022a, 2022b, 2024; Petlenko, 2024; Rajavuori & Huhta, 2020; Weber et al., 2016

The primary mechanisms for mobilizing financing include State/IFIs support, Equity, Debt, and Mezzanine financing. While states/sub-states/IFIs/Funds can act as shareholders or creditors, such cases should be regarded as a specific instance of equity or debt financing with the state or IFI/Fund acting as a commercial investor. Accordingly, this study does not consider cases of direct finance or commercial loans from states/IFIs. Instead, the rather limited resources available through the state/IFIs support mechanism, in accordance with the principles of blended finance (OECD, 2022a), should stimulate and unlock private commercial investment and expand the investor base (Symonenko, & Tsyganov, 2024). The key instruments employed for this purpose include power purchase agreements, tax incentives, credit and other guarantees, grants, concessional loans, and mezzanine financing instruments (such as loans with a first loss absorption function), among others. The application of these support mechanisms significantly mitigates market, credit, and other project risks and improves its financial indicators, in particular the debt burden in the context of a senior commercial debt. Consequently, investment risks become acceptable to providers of the bulk of financing, thereby enabling private investment inflow into the project (i. e., unlocking investment). Ideally, the role of states and IFIs is limited to addressing specific risks that commercial investors are reluctant to assume, namely those inherent in large-scale energy projects (construction and technical risks) and developing countries (political and regulatory risks), among others.

Equity financing typically accounts for 10-30% of the total investment and can be employed at all phases of an energy project, including the earliest phase - exploration and appraisal (where it is most commonly raised). This financing method does not require regular payments, does not increase the debt burden, and has a positive impact on the credit rating and balance sheet structure. However, its application is relatively limited, and in most cases, attracting additional equity financing dilutes the governance and ownership rights of other shareholders.

Debt financing accounts for up to 80% of the energy project investment. It is employed at later phases of project implementation compared to equity financing and is characterized by a rigid schedule of interest and principal payments. Debt financing may require collateral, increases the debt burden, and negatively affects the creditworthiness and balance sheet structure of the energy project. Creditors, however, do not acquire ownership or governance rights over the facility.

Mezzanine financing constitutes up to 20% of the total financing. It is a flexible method of capital raising, which combines features of both equity and debt and occupies an intermediate position between them. Mezzanine financing positively impacts the balance sheet structure and

creditworthiness of the project (in the context of its senior debt). This effect results from subordinating debt financing and/or reducing interest payments on senior debt, as long as the debt provider has the right to benefit from the project's value growth (equity upside) or a share of its profits. Although mezzanine financing accounts for up to 20% of the total capital expenditure of an energy project, it remains one of the key methods of raising capital, and its application enables the project to secure the full investment volume at an acceptable weighted average cost of capital. This process occurs through the mitigation of investment risks (and the reduction of investor returns) via their absorption by mezzanine instruments, thereby reducing them to a level acceptable to the primary capital providers. Consequently, it becomes possible to secure the bulk of project financing at relatively low rates, characteristic of issuances with high credit ratings.

We argue that in the context of requirements for capital raised for energy infrastructure assets, mezzanine financing largely meets the above-stated, rather contradictory principles for attracting investment in the energy sector. Moreover, it facilitates securing the bulk of financing, while ensuring some degree of compliance with these requirements. The alignment of mezzanine financing with the principles of securing investment in energy infrastructure is summarized in Table 2. Specifically, 1) Most forms of mezzanine financing do not entail transferring control or ownership of the energy project to the investor, which allows the government to retain control over strategically important facilities, if necessary. 2)–3) Mezzanine instruments offer investors higher returns compared to conventional debt instruments. Nevertheless, they serve as a leverage mechanism, enhancing the creditworthiness of an energy facility and its ability to attract new private commercial financing at a lower cost and, consequently, reducing the weighted average cost of capital, thereby positively affecting the cost of energy. 4) Forms of mezzanine financing allow for flexible structuring of the timing and conditions of investor remuneration, facilitating alignment of payments and investment returns with the energy project's cash flows. 5) The mezzanine capital provider usually occupies an intermediate position between shareholders and debt investors in terms of risk and return allocation, which is important for maintaining a fair balance among stakeholders. It should be noted that mezzanine investors are not appropriate parties to assume construction and technical risks inherent in energy projects, nor the political and regulatory risks inherent in developing countries. The handling and mitigation of these risks remain the prerogative of states and IFIs; however, this does not exclude the use of mezzanine instruments by these entities for such purposes (for instance, in the form of subordinated loans).

Table 2

The Alignment of Mezzanine Financing with Principles of Securing Investment in Energy Infrastructure	
Principles of Securing Investment in Energy Infrastructure	Characteristics of Mezzanine Financing
1. Principle of considering energy security and maintaining socio-economic stability aspects	Most forms of mezzanine financing do not involve transferring control or ownership over the energy project to the investor
2. Principle of mobilizing non-state financing	Mezzanine financing instruments enhance the creditworthiness, positively leverage debt financing, and reduce weighted average cost of capital (WACC) of the project
3. Principle of minimizing the cost of investment capital	
4. Principle of harmonizing cash flows from financial activities with those from the operational activities of the energy facility	Forms of mezzanine financing provide the ability to flexibly structure flexibly the timing and terms of investor remuneration payments and investment returns
5. Principle of a fair and relevant allocation of risks and returns (each specific type of risk should be managed by the party most competent and best adapted to handle it)	The mezzanine capital providers typically occupies an intermediate position between shareholders and debt investors in terms of risk and return allocation

Source: developed by the authors.

Generally, the main forms of mezzanine financing are classified (Kurylek, & Porebski, 2022; Nijs, 2014; Tetreova, & Svedik, 2018; Zatonatska, & Osypenko, 2025) into: Mezzanine equity: 1) Silent participation; 2) Preferred shares; Mezzanine debt: 3) Participating loans; 4) Participating bonds; 5) Subordinated loans; 6) Subordinated bonds; 7) Convertible loans; 8) Convertible bonds; 9) Bonds with warrants; 10) Securitization with tranching (utilizing senior and junior (mezzanine) tranches with different priority in receiving payments and repayment of investments).

We argue that securitization with tranching and subordinated debt financing (subordinated loans and bonds) are the most promising and relevant mezzanine financing instruments for application in energy facilities.

Securitization structured into senior and junior (mezzanine) tranches, which have different priorities in receiving payments and repayment of investments. Securitization is the conversion of assets (in the context of energy, this means cash flows generated by an energy facility) into bonds backed by these assets (asset-backed securities). Typically, it is structured through a special-purpose vehicle (SPV), which holds the rights to the project's cash flows and issues several tranches of bonds with varying priorities of claims and orders of loss absorption. The proceeds are then transferred to the investment project. Energy projects typically feature stable, long-term, and predictable cash flows secured by appropriate purchase agreements, while simultaneously requiring significant upfront capital investment. Securitization enables an energy facility to raise the required capital immediately by issuing bonds backed by future operational revenues. The use of tranches with different claim priorities allows for flexible risk management, attracting capital from investors with varying risk tolerance, and employing limited funding from the states or IFIs to buy out the youngest tranches (first-loss absorption), which constitute the smallest part of the issuance. Consequently, it facilitates the mobilization of the bulk of financing from private commercial investors, who are averse to high investment risks. Senior tranches with high credit ratings (and correspondingly low interest rates) and long tenors are particularly appropriate for institutional investors, such as pension funds or insurance companies.

Subordinated loans and bonds are forms of mezzanine financing that provide investors the right to receive interest income (the presence or absence of which may additionally depend on certain conditions – triggers); however, in the case of bankruptcy, their rights to the liquidation assets have a lower priority than other "senior" creditors. Under certain conditions, subordinated debt may be written down ahead of equity capital (serving as a first loss absorber). Energy projects typically require significant debt financing, yet most investors may be reluctant to assume the associated risks, especially at the early phases of project development. Securing a limited portion of financing from private investors ready to assume high risk in return for suitable reward or from the state/IFIs on concessional terms through subordinated debt instruments, improves the project's balance sheet structure and enhances the credit rating of senior, non-subordinated emissions. This, in turn, enables the full debt volume mobilization and positively affects the project's weighted average cost of capital, since the bulk of financing is raised at comparatively low interest rates, characteristic of issuances with high credit ratings.

In Ukraine's regulatory framework, securitization is currently regulated only in the context of mortgage bonds (Laws of Ukraine "On Mortgage Bonds" (Verkhovna Rada of Ukraine, 2005) and "On Capital Markets and Organized

Commodity Markets" (Verkhovna Rada of Ukraine, 2006). The regulatory framework for bonds backed by other assets (e.g., project future cash flows), as well as for the issuance of tranching securities with different seniority levels, is still in the initial formation stage. Subordinated loans are regulated only fragmentarily (Laws of Ukraine "On Financial Services and Financial Companies" (Verkhovna Rada of Ukraine, 2021b) and "On Banks and Banking Activities" (Verkhovna Rada of Ukraine, 2000)), simultaneously subordinated bonds are not explicitly addressed in the Law "On Capital Markets and Organized Commodity Markets". We conclude that the regulatory framework necessary for implementing and applying securitization with tranching and subordinated debt financing in Ukraine's economy has a significant potential for further improvement and constitutes a promising direction for future researches.

Considering the advanced global experience of applying the mezzanine method of attracting investment, its prevalence and importance for energy facilities financing, we argue that the introduction and implementation of mezzanine financing in Ukraine's economy is essential for the post-war recovery and further development of the energy sector. This capital mobilization method has the potential to become one of the key instruments, along with debt, equity, and state/IFIs financing. Moreover, it will expand the range of instruments available for state/IFIs support, as they will be able to employ mezzanine financial instruments alongside other financing tools. Considering the justification of mezzanine financing alignment with the key principles for mobilizing investment in the energy sector, we argue that this financing method is promising and relevant in the context of its implementation and application in Ukraine for the energy sector recovery and development. In particular, the priority mezzanine forms are securitization with tranching and subordinated debt financing (subordinated loans and bonds), for which Ukraine's institutional framework is still being established, reflecting the early stage of institutional development of these areas.

Accordingly, the Hypothesis of this study has been confirmed – the implementation and application of mezzanine forms of capital raising will have a positive impact on the post-war recovery and development of the Ukrainian energy infrastructure. We recommend prompt implementation and institutionalization of mezzanine financing instruments in Ukraine's economy, while further steps and measures for their institutionalization may serve as direction for future research.

Discussion and conclusions

The study demonstrates the significant impact of the environmental component on attracting investment in the energy sector and justified that the recovery of Ukraine's energy infrastructure should be pursued in alignment with the Sustainable Development Goals and ESG criteria.

It is substantiated that the key principles for mobilizing investment in the energy sector are: 1) principle of considering energy security and socio-economic stability aspects, 2) principle of mobilizing non-state (private) financing, 3) principle of minimizing the cost of investment capital, 4) principle of harmonizing cash flows from financial activities with those from operating activities of an energy facility, 5) principle of fair allocation of risks and returns (each specific type of risk should be managed by the party most competent and best adapted to handle it).

The study examined advanced global experience in financing energy infrastructure facilities, assesses the primary methods of capital mobilization (state/IFIs financing, equity, debt, and mezzanine), and proved that mezzanine

financing demonstrates significant relevance to the energy investment mobilization key principles.

It is justified that applying the mezzanine financing, which absorbs most of the default risks, enables the full volume of capital mobilization at an acceptable weighted average cost of capital. This phenomenon occurs due to a reduction to investment-grade level of both credit risks and the cost of senior debt financing, which in turn constitutes the bulk of the project's capital.

The study substantiates the high potential and relevance of the mezzanine financing for its implementation in Ukraine's economy with a view to post-war recovery and the sustainable development of energy facilities. The most relevant forms of mezzanine financing for implementation, institutionalization, and application in Ukraine's economy are identified as securitization with tranching and subordinated debt financing (subordinated loans and bonds). It is demonstrated that these mezzanine financial instruments can be employed both for raising capital from private investors on commercial terms and from the state/IFIs, with the subsequent unlocking of private investments in accordance with the principles of blended finance.

It is justified that the institutional framework for securitization with tranching and subordinated debt financing has the potential for further improvement and constitutes a promising area for future research.

It is recommended to ensure the prompt implementation and institutionalization of mezzanine financing forms in Ukraine's economy.

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МЕЗОНІННЕ ФІНАНСУВАННЯ ЕНЕРГЕТИЧНОЇ ІНФРАСТРУКТУРИ УКРАЇНИ У ПЕРІОД ПОВОЄННОГО ВІДНОВЛЕННЯ

Вступ. Урядом України розроблено Енергетичну стратегію до 2050 р., що передбачає посилення енергетичної безпеки та незалежності й запроваджує цілі щодо енергоефективності, екологічної безпеки, зниження вуглецевих викидів тощо. Повоєнна відбудова з одночасною модернізацією енергетичного сектору України вимагатиме мобілізації значних фінансових ресурсів, тому актуалізується питання дослідження провідного міжнародного досвіду залучення інвестицій в енергетичну інфраструктуру. Метою статті є обґрунтування перспективних методів фінансування енергетичних об'єктів для впровадження та використання в українській економіці в період повоєнного відновлення.

Методи. Фактологічний і ситуаційний аналіз, синтез, дедукція, методи системного підходу та теоретичного узагальнення.

Результати. Проаналізовано світовий досвід застосування і поєднання методів фінансування енергетичної інфраструктури. Сформульовано основні принципи залучення інвестицій у сучасну енергетику. Дослідження містить аналітичні висновки з обґрунтуваннями щодо перспектив і актуальності впровадження та застосування в Україні мезонінного фінансування для повоєнного відновлення та розвитку енергетики. Окремо визначено найбільш пріоритетні й оптимальні мезонінні форми залучення інвестицій у енергетичний сектор.

Висновки. Визначено основні принципи залучення інвестицій в енергетичний сектор, а саме: врахування аспектів енергетичної безпеки та соціально-економічної стабільності, мобілізація недержавного фінансування, мінімізація вартості капіталу, гармонізація грошових потоків енергетичного проєкту, справедливий розподіл ризиків і доходу. На основі світового досвіду виконано порівняння основних методів мобілізації капіталу в енергетичну інфраструктуру (від держави / МФО, акціонерний, борговий, мезонінний). Обґрунтовано перспективність і актуальність мезонінного фінансування для впровадження і використання в українській економіці. Найоптимальнішими формами мезонінного фінансування для енергетики визначено сек'юритизацію з траншуванням і субординоване боргове фінансування. Встановлено, що інституційне забезпечення цих інструментів залучення капіталу має потенціал для вдосконалення, та є перспективним напрямом подальших досліджень. Рекомендовано якнайшвидше впровадження й інституціалізацію мезонінного фінансування в українську економіку.

Ключові слова: мезонінне фінансування, фінансування енергетичної інфраструктури, форми мезонінного фінансування, повоєнне відновлення енергетичного сектору України, сек'юритизація з траншуванням, субординований борг.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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STRATEGY FOR INVESTMENT LEADERSHIP OF THE TERRITORIAL COMMUNITY: METHODOLOGICAL APPROACH TO EVALUATION

Background. The article substantiates the necessity of strengthening the competitiveness of the territorial communities of Ukraine through a rethinking of their investment leadership strategy with the aim of ensuring sustainable competitive advantages. The dynamic conditions of the functioning of the external and internal environment of the territorial communities of Ukraine necessitate the improvement of the methodological tools for assessing their investment attractiveness. The purpose of this article is to develop a methodological approach to the assessment of the level of investment attractiveness as the dominant integral indicator in the investment leadership strategy of the Irpin city territorial community.

Methods. The sources of data for the development of the methodological approach were the author's empirical research and the experience of participation in the expert group on the development of the Post-war Development Strategy of the Irpin city territorial community for 2025–2035. In this work, a combined approach was applied on the basis of financial and general methods, grounded in expert assessment of a number of structural blocks. For this purpose, the most optimal and significant initial parameters were proposed and analysed: economic potential and competitive conditions; infrastructure and environment; administrative support of entrepreneurship; development of the socio-economic sphere; and regulatory support for community development. The parameters were given substantive characteristics, assigned a coefficient of comparative significance, determined a coordinated final assessment, and the distance of the target indicator. According to the developed qualitative evaluation scale of the values of the integral indicator of investment attractiveness, the ranking of these parameters was carried out by average values. Averaged values of the assessment parameters of investment attractiveness of the Irpin city territorial community were obtained by separate structural blocks.

Results. The results of the assessment showed that the most attractive factors determining investors interest in investing capital in the territorial community of Irpin and its conglomerate are the prospects and substantiation of the Community Development Strategy with a time horizon of certainty until 2035, on which a group of domestic and international experts is currently working intensively; the available qualitative results of the implementation of the Program of socio-economic and cultural development of the Irpin city territorial community; the provision of equal opportunities for participation in public procurement procedures; resource and information support for entrepreneurship; transparency of permitting procedures in construction; consideration of public opinion in addressing issues of planning and development of territories; the substantiation and quality of the urban planning concept, as well as the favorability of the competitive environment for the entry of new entrepreneurs into the market.

Conclusions. Such components as the level of development of the industrial production sector and the existing economic potential of the community, the effectiveness of measures of financial, credit, and investment support for entrepreneurship, and the formation of favourable conditions for the realisation of the entrepreneurial potential of the Irpin city territorial community require substantial attention to enhance investment attractiveness.

Keywords: leadership, investment attractiveness, methodological approach, territorial community, Irpin.

Background

The contemporary challenges of a globalised world place critically important tasks of strategic transformations before national governments. First and foremost, this concerns the necessity of forming competitive advantages which, over a sustainable period, will make it possible to use them to ensure the economic growth of communities and territories and to improve the standard of living of citizens. A number of legislative changes in Ukraine, motivated by the harmonisation of the regulatory and legal framework and the unification of procedures with the European Union, have conditioned the implementation of territorial reform and the creation of new innovative concepts of urban development.

Undoubtedly, the systemic military factors of influence have altered and continue to alter the potential of territorial communities in Ukraine, which once again actualises the revision of their reserves and the development of an effective leadership strategy for them, based on the enhancement of investment attractiveness potential. Only market approaches and the strengthening of competitive advantages, and not a "donation-based economy", are capable of ensuring the sustainable development and prosperity of territorial communities.

One of such decisions was the recognition by the Irpin city territorial community of the irreversibility of the course of developing its own post-war development strategy (Order No. 97 was issued on 19 June 2023 by the Mayor of Irpin), to be the first to ensure investment leadership on a competitive basis. In 2023, the city leadership engaged a strong group of domestic and international experts from the academic environment, business, representatives of civil society, government, and institutions of the European Union, the United States, and others (Order No. 194 was issued on 7 November 2023 by the Mayor of Irpin), which is currently working out effective transformational solutions. The dynamics of political upheavals and military factors constantly adjust the working process of the expert group (Order No. 215 was issued on 26 September 2024 by the Mayor of Irpin) and have brought the realisation that the Irpin city territorial community must develop the Strategy of Post-war Development of the Irpin city territorial community for 2025–2035, to consolidate the strategic trend of increasing investment attractiveness based on strengthening its own competitive potential and resilience to shocks. This strategic document is to become an example for the development of

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other territorial communities in Ukraine and to demonstrate the best practices of innovative solutions of the international expert group to ensure the investment leadership of the territorial community.

This article aims to develop a methodological approach to evaluating the level of investment attractiveness as a key indicator in the Irpin city community's investment leadership strategy.

Literature review. Effective investment leadership at the territorial community level necessitates a multifaceted strategy that integrates economic governance, smart specialisation, stakeholder engagement, and spatial equity considerations. The methodological assessment of investment attractiveness must therefore incorporate diverse determinants, including governance models, digital and green transitions, regional infrastructure, fiscal competitiveness, and socio-economic resilience. Existing literature offers robust empirical foundations to guide such strategic positioning.

Territorial communities need to invest in creative industries and information and analytical institutions as the fundamental drivers of the development of public administration and the management of various types of economic activity. This is primarily necessary for the successful preparation and implementation of creative investment projects of national importance (Bugrov, Sitnicki, & Serbin, 2021). Proactive management tools based on the application of creative financial leadership in the successful practice of developing city territorial communities have made it possible to identify current trends in boosting the investment attractiveness of Ukrainian cities (Sitnicki, Prykaziuk, & Sitnicka, 2023). The investment potential of territorial communities is increasingly shaped by the flow and utilisation of FDI, which contributes to sustainable development and regional integration when accompanied by strong governance institutions and favourable legal environments (Bagirzadeh et al., 2025; Kaddouri, & Benelbar, 2024). At the subnational level, fiscal incentives and investment attractiveness mechanisms, such as competitive tax regimes, transparency policies, and public investment tools, play a critical role in shaping business climate and trust (de Moraes e Soares, & Pinheiro, 2023; Dobrovolska et al., 2024; Nguyen Son, & Phan Thanh, 2025). The presence of shadow economies, weak judicial enforcement against corruption, and unpredictable regulatory burdens erode the fairness of the investment environment, underscoring the need for systematic diagnostics (Dobrovolska et al., 2024).

Investment strategies of territorial communities are also embedded in the broader frameworks of smart governance, regional specialisation, and urban development. The implementation of the JRC smart specialisation methodology in Ukraine has shown promise in fostering regional innovation and clustering, though the alignment of local resources with national policy goals remains inconsistent (Ivashchenko et al., 2020; Polishchuk et al., 2019). The growing role of e-governance, citizen feedback mechanisms, and co-creation practices further shape the perception of transparency and participatory planning, which in turn enhances investment confidence and legitimacy (Kuzior et al., 2022; 2023; Oe, & Yamaoka, 2024; Slingerland et al., 2024; Ylipulli, Hämäläinen, & Palo, 2025).

Branding and strategic communication also contribute significantly to a territory's investment image. Smart city branding, especially when oriented toward resident perceptions and quality-of-life indicators, can serve as a soft attractor for capital, talent, and innovation (Grębosz-

Krawczyk, & Zakrzewska-Bielawska, 2024). However, the branding impact may be diminished if not coupled with material support for start-ups, digital infrastructure, and sustainable planning models (Kuzior et al., 2025; Springs, 2024a; Maricuț et al., 2025). Moreover, the disparity between smart city rankings and entrepreneurial ecosystems has been noted as a systemic tension requiring more granular analysis (Kuzior et al., 2025).

Socio-economic and environmental factors remain indispensable in territorial investment assessment. Spatial equity in utility pricing, such as electricity, affects not only household well-being but also regional competitiveness (Mentel et al., 2018). The development of tourism and health-based clusters, as seen in Yerevan or Japanese Blue Zones, provides evidence of how non-industrial sectors contribute to territorial investment attractiveness and community resilience (Orbelyan, 2024; Oe, Weeks, & Sartamorn, 2025). Meanwhile, leadership strategies must also navigate globalisation and liberalisation dynamics, as shifts in global capital flows and trade integration exert complex influences on regional economies (Ojaghlou, & Tercan, 2024; Yoon, 2023).

Local public investment behaviour is also shaped by structural and institutional factors. Panel data analyses from Morocco and South Africa highlight how institutional frameworks, socio-political cohesion, and financial decentralisation directly influence municipal-level investment patterns and financial viability (El Bakkali, & Guati, 2025; Sitishe et al., 2023; Ntshangase, Makole, & Msosa, 2024). In the Ukrainian context, the causal relationship between fiscal self-sufficiency of communities and local economic development highlights the importance of reliable revenue systems, strategic planning, and intergovernmental coordination (Voznyak et al., 2023).

The role of innovative and ethical leadership is a cross-cutting enabler of investment strategies. Leadership styles that promote inclusivity, ethical norms, and innovation readiness contribute not only to sound economic management but also to social capital formation and institutional legitimacy (Bian, & Wang, 2024; Springs, 2024a; Yetongnon, & Kasztelnik, 2024). In the context of smart and green cities, leadership that embraces digital agency and citizen-led innovation fosters more just and sustainable investment environments (Ylipulli, Hämäläinen, & Palo, 2025; Kuzior et al., 2022). At the rural level, the global envelope method offers a novel approach to assessing local economic potential by capturing spatial disparities and infrastructure deficits (Pártlová, 2023).

Ultimately, territorial communities must integrate the principles of smart governance, ethical leadership, and inclusive development into their investment strategies. Governance systems that align with global ESG trends, such as the future of Islamic real estate investment trusts or adaptive finance mechanisms, also provide adaptable models for territorial actors (Hicham, Abdellatif, & Karim, 2024). Cities that demonstrate readiness to integrate policing technologies, health innovations, and transparent communication platforms are more likely to position themselves as leaders in the next phase of regional competitiveness (Springs, 2024b; Vitálišová et al., 2024).

The literature suggests that the investment leadership strategy of territorial communities must be multi-dimensional, data-driven, and ethically grounded. Methodological assessment tools should account for fiscal, institutional, social, and digital factors. Moreover, resilient and inclusive governance structures are indispensable for enhancing a community's investment attractiveness in the contemporary global economy.

Methods

The sources of data for the development of the methodological approach to assessing the investment attractiveness of the Irpin city territorial community were the author's empirical research, the experience of participation in the expert group on the development of the Post-war Development Strategy of the Irpin city territorial community for 2025–2035, focus groups and working meetings during 2022–2025 with representatives of the entrepreneurial ecosystem, the creative intellectuals, architects, the educational environment, engineers, technologists, representatives of the healthcare sphere and compliance with the community's environmental standards, representatives of emergency services, law enforcement bodies, civil servants of the apparatus of the Irpin City Council, deputies, representatives of student self-government, representatives of the creative industries, current investors, experts of the European Commission, the USA, the United Kingdom, and other interested stakeholders.

In this work, a combined approach was applied on the basis of tools of financial and general methods of financial stability, liquidity, business, and market activity of the Irpin city territorial community. The developed author's methodological approach also takes into account monitoring data on the implementation of the Programme of socio-economic and cultural development of the Irpin city territorial community (Resolution No. 3113-41-VIII of 9 May 2024 by the Irpin City Council) and is grounded in expert assessment of some structural blocks for determining the integral indicator of investment attractiveness.

For this purpose, the most optimal and significant initial parameters of the investment attractiveness of the Irpin city territorial community were proposed and analysed: economic potential and competitive conditions; infrastructure and environment; administrative support of entrepreneurship; development of the socio-economic sphere; and regulatory support for community development. The parameters were given substantive characteristics, assigned a coefficient of comparative significance, determined a coordinated final assessment, and the distance of the target indicator. According to the developed scale of qualitative evaluation of the values of the integral indicator of investment attractiveness, the ranking of these parameters was carried out by average values. Averaged values of the assessment parameters of investment attractiveness of the Irpin city territorial community were obtained by separate structural blocks.

Results

The investment attractiveness of the Irpin city territorial community under the present conditions is determined by several structural blocks and factors, namely:

1. The economic potential of the Irpin city territorial community is formed by enterprises of the manufacturing industry, the chemical industry, as well as the production of rubber and plastic products, the production of furniture, non-metallic products (building materials); the production and distribution of electricity, gas and water (95% of pre-war industrial production accounted for the non-state sector). The necessity of strengthening the existing economic potential and ensuring its development conditioned the need for large-scale investments, while at the same time the Irpin city territorial community suffered significant destruction as a result of external aggression. The industrial enterprises located on the territory of the community were considerably affected and require restoration and comprehensive support.

2. The existing system of entrepreneurship support and the general state of entrepreneurship in the territorial

community are at a satisfactory level, ensuring the formation of favourable conditions for the disclosure and development of the entrepreneurial potential of the territorial community. At the same time, among the total number of registered small and medium-sized enterprises in the community, the overwhelming majority (98.9%) were micro-enterprises. An important component of improving entrepreneurship support was the introduction in 2020 of the Programme for the Development of Small and Medium-sized Enterprises (SME) of the Irpin city territorial community for 2021–2023, as well as in 2022 the "eRobota" programme for the provision of micro-grants for the organisation and development of own businesses, which overall have been implementing the set tasks quite successfully. In particular, financial, credit, and investment support for small entrepreneurship is envisaged, namely: stimulation of entrepreneurial activity; increasing the effectiveness of interaction between community business and government to strengthen the investment activity of the region; promoting economic stability for business entities; and the introduction of mechanisms of financial and credit support for SMEs. However, the full-scale invasion and armed aggression against Ukraine, to some extent, hindered the developed initiatives. At present, despite various difficulties, the revival of community development and the support of its entrepreneurial potential is taking place.

In the direction of implementing the tasks of supporting entrepreneurship of the Irpin city territorial community, there are currently functioning: an entrepreneurship support fund, two investment funds/companies, one business centre, and four public associations of entrepreneurs.

3. It is necessary to particularly note the favourability of the competitive environment of the Irpin city territorial community concerning the entry carpentry and joinery products, furniture, metal products, jewellery; funeral services; hairdressing services, etc.).

Small and medium-sized enterprises are provided with equal access to participation in public procurement procedures. The resource and information support of small entrepreneurship envisages measures for the creation of a mechanism of equal opportunities for all business entities. The sector of communal property of the Department of Infrastructure, Investment Development, and Housing and Communal Services of the Executive Committee of the Irpin City Council has created a database of unused non-residential premises of communal ownership, which are offered for lease or sale to business entities. This information is posted on the official city website on the Internet and is regularly updated.

4. The authorised bodies of local government provide the full spectrum of administrative services, in particular through the use of modern web platforms and a centralised electronic office for the provision of administrative services. Their quality, accessibility, and transparency undoubtedly deserve high appraisal. The Centre for Administrative Services "Transparent Office", based on engaging external financial consultants, provides information on available lending programmes and banking instruments accessible for entrepreneurs when starting their own business. The activities of the Centre are aimed at providing business and entrepreneurial entities with the opportunity to carry out document circulation in one place and to obtain the necessary permits and approvals for conducting business or entrepreneurial activity. It is also possible to use the banking services of a mobile branch of "PrivatBank" concerning the issuance of cards, payment of utility bills, processing of deposits, insurance policies, etc. The introduced measures

significantly reduce the time for obtaining authorising documents in the field of economic activity, create favourable conditions for the development of entrepreneurship, the overcoming of administrative barriers, and so forth.

An extremely important factor for the development of entrepreneurial activity, the effectiveness of which contributes to increasing the investment attractiveness of the region, attracting domestic and foreign investments, and the application of advanced technologies, is the practice introduced by the Irpin State Tax Inspectorate of the Main Department of the State Tax Service in Kyiv Region of providing business entities with accompanying informational support regarding current tax legislation and various instruments of support for SMEs.

Cooperation has been established with an extensive network of partners, enterprises and organisations regarding the search for financial opportunities and the establishment of links with potential investors, the implementation of projects for the restoration of the Irpin city territorial community, the corresponding support and implementation of joint projects and programmes, informational partnership support of activities, and the promotion of the protection of economic, social, investment and other common interests.

5. Under the conditions of martial law, enterprises have to overcome the consequences of infrastructure destruction and adapt to new conditions and challenges that confront them. A slight decline in the solvency of recipients of public utilities has been recorded; there is destruction of the housing stock, and a need for unplanned repairs. However, the active restoration of the community's engineering and transport infrastructure continues. Programmes of external support for financing the reconstruction of infrastructure are being implemented, in particular, large-scale financing is being attracted within the framework of the President's initiative "United24" and the State Programme of the Fund for the Elimination of the Consequences of Armed Aggression.

Exemplary transparency of permitting procedures in construction, consideration of public opinion in resolving issues of planning and development of territories, and a well-founded and high-quality urban planning concept have been noted.

It is worth highlighting the rather high level of development of the transport infrastructure of the Irpin city territorial community, with projects for its modernisation and improvement being implemented. At present, a whole range of companies providing internet connection services are operating, and in addition, the community has a fairly extensive postal network comprising 25 branches (as of the beginning of 2024).

6. At the same time, martial law in Ukraine and crisis processes in the Ukrainian economy have led to the curtailment of production and an increase in the number of unemployed people (the activity of job seekers has risen – the number of responses to vacancies, compared with the previous month, increased by 35%). The largest number of available vacancies is for workers and service personnel (40.5%), including sales specialists, IT and Internet specialists, and transport sector professionals (9%), as well as in construction (almost 6%). In terms of salary levels, Irpin, to some extent, lags behind Kyiv, where, on average, companies offer more than 25,000 UAH in monthly wages (as of the end of 2023); moreover, the largest number of vacant job offers is also open in the city of Kyiv (40.1% of the offers summarised by the State Employment Service).

Among the registered unemployed, 56% were persons over the age of 45 and those with 10 or fewer years remaining until retirement; 15% of the total number of registered unemployed were persons under the age of 35. The main causes of youth

unemployment are the mismatch between the volume and areas of vocational training and the needs of the economy and the labour market, the insufficient level of quality of vocational training, and the unsatisfactory working conditions offered to young people in specific workplaces.

Positive changes are taking place in the demographic development, in the humanitarian sphere, and in the healthcare sector of the community, with consistent support being provided to families and youth. Powerful educational initiatives are being implemented with the involvement of sponsorship and charitable support for the relevant activities, extensive cooperation has been established with the scientific community in the field of developing the educational space, and due attention is being paid to cultural and artistic mass events.

7. The state of law and order and the fight against crime, as well as the timely conduct of preventive work among risk groups and business entities of the community's territory, have a positive impact on the investment climate and socio-economic development of the community. High quality has been ensured in monitoring the threat of fires, detecting, preventing, and extinguishing outbreaks, and creating favourable conditions for the population's life activities. At the same time, work is being carried out on the construction of new additional civil protection shelters and the improvement of the arrangement of existing ones. The environmental factor is also quite favourable for the development of the territorial community: a low level of pollution of air, soils, and the hydrosphere, water resources, surface and underground waters, as well as the absence of large landfills and the storage of hazardous toxic substances.

8. The prospect of creating by 2030 a technopark between Irpin and Mykhailivka-Rubezhivka to achieve competitive leadership in attracting Ukrainian and foreign industries, drawing in innovative investments, and ensuring sustainable support for entrepreneurial activity is evaluated extremely positively. Accordingly, the planned opening of the International Irpin Exhibition and Creative Conference Centre "IRPIN ART CENTRE" will additionally influence the interest of various parties in the implementation of joint entrepreneurial projects.

In the modern conditions of urbanisation and the problems it generates, the implementation of the developed strategic concept of introducing recreational infrastructure on the territory of the Irpin city territorial community and the Irpin region, the restoration of the function of the Irpin forests as the lungs of Kyiv, and the integration of the Irpin forest, parks and squares into a large green zone with a network of tourist routes and large-scale land art is extremely attractive for attracting capital. In addition, the availability of land for the construction of private housing stock and industrial facilities also, to some extent, contributes to investors' interest in capital investment.

Additionally, it is worth noting the priorities concerning the development of infrastructure for the effective management of household waste, the provision of an appropriate technological process of waste recycling and sorting, and the neutralisation and disposal of hazardous waste on the basis of involving the most modern technologies.

Based on the results of the conducted analysis of the investment attractiveness of the Irpin city territorial community, an evaluation table was formed indicating the key parameters taken into account and detailing their importance (Table 1).

Based on the results of the final assessment, the integral indicator of investment attractiveness of the Irpin city territorial community amounted to 4.006584 (coefficient), which, according to the corresponding value scale (Table 2), is characterised as high investment attractiveness.

Table 1

**Initial parameters and their assessment for determining the integral indicator
of investment attractiveness of the Irpin city territorial community**

№ / row code	Parameters	Coefficient of comparative significance	Coordinated final assessment (max = 10 points)	Distance of the target indicator
1.	Economic potential and competitive conditions			
1.1.	Level of development of entrepreneurship, system of entrepreneurship support, formation of favourable conditions for the realisation of the entrepreneurial potential of the territorial community	1	7.50	0.0625
1.2.	Effectiveness of programmes and corresponding measures of financial, credit, and investment support for entrepreneurship	1	6.25	0.140625
1.3.	Level of development of the industrial production sector, the existing economic potential of the community, and the prospects for its development	1	6.00	0.160000
1.4.	Favourability of the competitive environment regarding the entry of new entrepreneurs into the market, the establishment of their own businesses, the absence of bureaucratic obstacles in the implementation of business projects, and the provision of the principle of equal opportunities for all business entities	2	9.75	0.000625
2.	Infrastructure and environment			
2.1.	State of transport infrastructure, provision of internet connectivity and its quality, and the extent of postal branches	2	.	0.015625
2.2.	State of development and restoration of infrastructure, housing construction, and availability of external support programmes for financing the community's infrastructure reconstruction	2	8.50	0.022500
2.3.	Quality of monitoring of fire threats, detection, prevention, and extinguishing of outbreaks, provision of favourable living conditions for the population, and arrangement of civil protection shelters	2	8.25	0.030625
2.4.	Level of pollution of air, soils, and the hydrosphere, water resources, surface and underground waters, absence of large landfills, and storage of hazardous toxic substances	2	7.25	0.075625
3.	Administrative support of entrepreneurship			
3.1.	Transparency of permitting procedures in construction, consideration of public opinion in resolving issues of planning and development of territories, substantiation, and quality of the urban planning concept	2	9.75	0.000625
3.2.	Range, quality, and transparency of administrative services provided by the authorised bodies of local government, and availability of web platforms for the provision of administrative services	2	9.50	0.002500
3.3.	Provision of equal opportunities for participation in public procurement procedures, resource and information support for entrepreneurship	1	9.75	0.000625
3.4.	Provision of accompanying informational support to business entities regarding current tax legislation and the support of SME	2	9.25	0.005625
4.	Development of the socio-economic sphere			
4.1.	State of the social sphere, employment of the population, correspondence of workers' qualifications to labour market demands, and average monthly salary	2	6.75	0.105625
4.2.	Demographic development, support of families and youth, the humanitarian sphere, and the healthcare sector	2	8.75	0.015625
4.3.	Educational initiatives, sponsorship and charitable support of activities, extensive cooperation with the scientific community in the field of developing the educational space, and implementation of cultural and artistic mass events	2	9.50	0.002500
4.4.	State of law and order and the fight against crime, timely preventive work among risk groups and business entities of the community's territory	1	9.25	0.005625
5.	Regulatory support for community development			
5.1.	Effectiveness of the implementation of the Programme of socio-economic and cultural development of the Irpin city territorial community for 2023 and the main directions of development for 2024–2025	1	9.75	0.000625
5.2.	Details, prospects, and substantiation of the Development Strategy of the Irpin city territorial community for 2022–2032	1	10.00	0.000000
5.3.	Availability of programmes for the development of innovative infrastructure, relevant clusters, the construction of technology parks, the creation of venture funds, etc.	1	8.25	0.030625
5.4.	Availability of agreements on long-term cooperation in the direction of implementing joint projects, searching for and attracting potential investors, and protecting common interests	2	8.75	0.015625

Source: author's development.

Table 2

Scale of qualitative assessment of the values of the integral indicator of investment attractiveness

No	Indicator value (coefficient)	Attractiveness characteristic
1	From 4.51 to 5.00	Excellent attractiveness
2	From 4.00 to 4.50	High attractiveness
3	From 3.51 to 3.99	Average attractiveness
4	From 3.00 to 3.50	Below-average attractiveness
5	From 2.51 to 2.99	Low attractiveness
6	From 2.00 to 2.50	Very low attractiveness

Source: author's development.

The impact of the component parameters of investment attractiveness of the Irpin city territorial community on the final result, according to their average values without weighting coefficients, is presented in Fig. 1.

Figure 2 presents a diagram that reveals the investment attractiveness of the Irpin city territorial community by aggregated blocks of evaluation parameters.

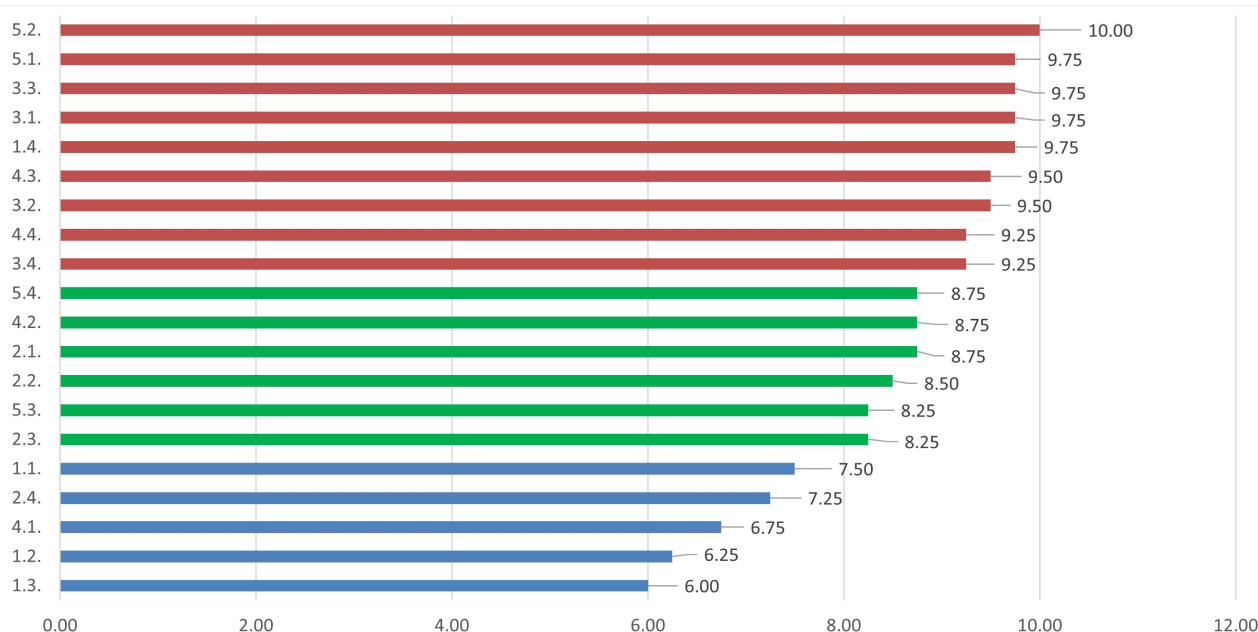


Fig. 1. Ranking of the parameters of investment attractiveness of the Irpin city territorial community by average values

Source: author's development.

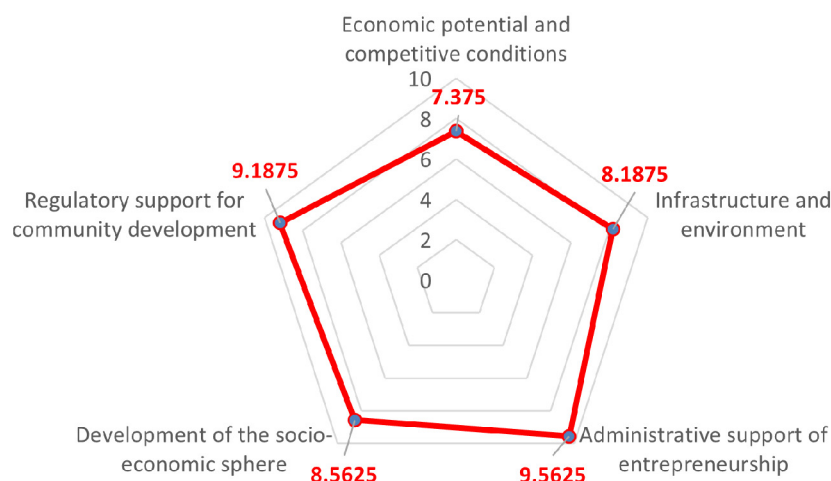


Fig. 2. Averaged values of the evaluation parameters of investment attractiveness of the Irpin city territorial community by separate structural blocks

Source: author's development.

Discussion and conclusions

The investment leadership strategy of the Irpin city territorial community must be based on the systematic strengthening of the community's competitive advantages, which increase its level of investment attractiveness and act

as drivers for attracting investors and other interested stakeholders. Thus, the most attractive factors determining investors interest in investing capital in the territorial community of Irpin and its conglomerate are the prospects and substantiation of the Community Development Strategy

with a time horizon of certainty until 2035, on which our international group of experts is currently working intensively; the available qualitative results of the implementation of the Programme of socio-economic and cultural development of the Irpin city territorial community; the provision of equal opportunities for participation in public procurement procedures; resource and information support for entrepreneurship; transparency of permitting procedures in construction; consideration of public opinion in addressing issues of planning and development of territories; the substantiation and quality of the urban planning concept, as well as the favourability of the competitive environment for the entry of new entrepreneurs into the market.

The authorised bodies of local government provide a wide range of administrative services with access to specialised web platforms and the provision of accompanying informational support regarding current tax legislation and the support of small and medium-sized enterprises. The state of law and order is maintained at a rather high level, the level of criminalisation of the environment is low, and constant preventive work is carried out in the direction of combating crimes among the relevant risk groups.

At the same time, such components as the level of development of the industrial production sector and the existing economic potential of the community, the effectiveness of measures of financial, credit and investment support for entrepreneurship, and the formation of favourable conditions for the realisation of the entrepreneurial potential of the territorial community require substantial attention with regard to the necessity of increasing investment attractiveness.

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СТРАТЕГІЯ ІНВЕСТИЦІЙНОГО ЛІДЕРСТВА ТЕРИТОРІАЛЬНОЇ ГРОМАДИ: МЕТОДИЧНИЙ ПІДХІД ДО ОЦІНЮВАННЯ

В с т у п . Обґрунтовано необхідність посилення конкурентоспроможності територіальних громад України через переосмислення їхньої інвестиційної стратегії лідерства з метою забезпечення сталих конкурентних переваг. Динамічні умови функціонування зовнішнього та внутрішнього середовища територіальних громад України спонукають до вдосконалення методичного інструментарію до оцінювання їхньої інвестиційної привабливості. Ціллю цієї статті є розроблення методичного підходу до оцінювання рівня інвестиційної привабливості як домінуючого інтегрального показника у стратегії інвестиційного лідерства Ірпінської міської територіальної громади.

М е т о д и . Джерелами даних для розроблення методичного підходу виступили авторські емпіричні дослідження та досвід роботи в експертній групі з розроблення Стратегії повсякденного розвитку Ірпінської міської територіальної громади на 2025–2035 рр. В цій роботі застосовано комбінований підхід на основі інструментів фінансових і загальних методів, що ґрунтується на експертному оцінюванні низки структурних блоків. Для зазначеної цілі запропоновано та проаналізовано найбільш оптимальні та вагомі початкові параметри: економічний потенціал і конкурентні умови; інфраструктура і середовище; адміністративний супровід підприємництва; розвиток соціально-економічної сфери; нормативне забезпечення розвитку громади. Параметрам було надано змістовну характеристику, вказано коефіцієнт порівняльної значущості, визначено узгоджену підсумкову оцінку та відстань цільового показника. За розробленою шкалою якісного оцінювання значень інтегрального показника інвестиційної привабливості проведено рейтингування цих параметрів за середніми значеннями. Отримано усереднені значення оціночних параметрів інвестиційної привабливості Ірпінської міської територіальної громади за окремими структурними блоками.

Р е з у л ь т а т и . Результати оцінювання показали, що найпривабливішими чинниками, що зумовлюють зацікавленість інвесторів у вкладенні капіталу в територіальну громаду Ірпеня і його конгломерату, є перспективність та обґрунтованість Стратегії розвитку громади із часовим горизонтом визначеності до 2035 р. над розробленням якої нині посилено працює група вітчизняних і міжнародних експертів; наявні якісні результати реалізації Програми соціально-економічного та культурного розвитку Ірпінської міської територіальної громади; забезпечення рівних можливостей щодо участі у процедурах державних закупівель; ресурсного й інформаційного забезпечення підприємництва; прозорість дозвільних процедур у будівництві; урахування громадської думки під час розв'язання питань планування та будови території; обґрунтованість та якість містобудівної концепції, а також сприятливість конкурентного середовища щодо виходу на ринок нових підприємств.

В и с н о в к и . Потребують суттєвої уваги щодо необхідності підвищення інвестиційної привабливості такі її складові, як рівень розвитку промислового сектору виробництва та наявний економічний потенціал громади, ефективність заходів фінансово-кредитної та інвестиційної підтримки підприємництва, формування сприятливих умов для розкриття підприємницького потенціалу Ірпінської міської територіальної громади.

К л ю ч о в і с л о в а : лідерство, інвестиційна привабливість, методичний підхід, територіальна громада, Ірпінь.

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GENDER COMPONENT OF THE RISKS OF THE BUDGET PROCESS IN UKRAINE

Background. *This article is devoted to the study of gender aspects of the risks of the budget process in Ukraine, particularly the implementation of gender budgeting, as well as the assessment of risks that arise during the implementation of management decisions at all stages of the budget process of public authorities in Ukraine.*

Methods. *To carry out an in-depth analysis of the scientific problem under study, the article uses general scientific and special methods, including comparison, specification, typology, etc.*

Results. *The article presents the results of the analysis of the institutional and legal environment of gender aspects of the risks of the budget process at the state level. Following this analysis, the authors provide a list of risks at each stage of the budget process and possible consequences of failure to consider the gender aspects of these risks.*

Conclusions. *Based on the study, the authors provide examples of risks at all stages of the budget process regarding gender aspects, characterize them, and emphasize the need to continue developing in-depth methodological support for assessing the risks of the budget process concerning gender aspects at all stages of its implementation by the state authorities of Ukraine.*

Key words: *budget process, budget legislation, gender aspects, gender budgeting, gender responsive budgeting, risks of the budget process, stages of the budget process, risk management of the budget process.*

Background

The direction of gender budgeting in Ukraine began its development relatively recently, as evidenced by the state's recognition of the importance of gender issues at the legislative level only in 2005. This was done through the adoption of the Law of Ukraine "On Ensuring Equal Rights and Opportunities for Women and Men" (Verkhovna Rada of Ukraine, 2005). The practical implementation of gender aspects at the level of the main managers of budget funds took place in 2014, through the introduction by the Ministry of Finance of Ukraine of a pilot project to conduct gender budget analysis in two sectoral ministries, in particular the Ministry of Social Policy of Ukraine and the Ministry of Youth and Sports of Ukraine.

It should be noted that the reform on the implementation of gender budgeting in Ukraine began its implementation with the technical support of the project "Gender-oriented budgeting in Ukraine" (Project GOB), which was funded by the Swedish International Development Agency (SIDA). For the first time, this project introduced the use of gender-oriented budgeting as one of the tools for achieving gender equality in Ukraine, which was aimed at increasing the efficiency of the use of budget funds and other state financial resources.

The relevance of the topic of the study of the gender component of the risks of the budget process is due to its direct impact on the effectiveness and fairness of the implementation of state financial policy. Despite the direction of the budget to meet the needs of society, in particular, men and women, as well as various social groups of the population, the lack of gender sensitivity in this matter can lead to significant disproportions and inefficiency in the use and distribution of public financial resources.

The purpose of the study is to analyze the institutional and legal environment for the implementation of gender

budgeting at the state level, as well as to identify the possible risks that accompany the implementation of management decisions of authorized officials during the implementation of gender budgeting at all stages of the budget process. This, in turn, will make it possible to prepare proposals for more effective use of available state financial resources and minimize the consequences of the impact of such risks. The objectives of the study are defined: disclosure of the essence and content of the main terms and concepts used in the consideration of this process; analysis of the gender legislation of Ukraine; study of the impact of non-inclusion of gender aspects at various stages of the budget process with the determination of the possible consequences of such impact; justification of the need to integrate gender aspects into the budget process at all stages, etc.

Literature review. Among Western researchers of gender issues in economic theory and the implementation of the gender approach in the budgeting process, the following scholars can be distinguished: D. Budlender, G. Becker, M. Bosnic, E. Villagomez, H. Ebner, D. Elson, E. Klatzer, R. Xelo, S. Nikolin, A. Golemac-Powell, T. Polzer, M. Stewart, A. Ferrando, D. Frey, L. Shtangl, and others.

It should be emphasized that the domestic scientific school in this field is only in the process of formation. Currently, the following Ukrainian experts in the field of gender aspects and gender budgeting can be identified: O. Vladysavlevych, S. Harashchenko, T. Ivanina, O. Kyselova, M. Kolodii, T. Martsyniuk, O. Ostapchuk, O. Rudenko, N. Riabushenko, O. Tsiupa, N. Chermoshentseva, O. Cherniuk, and others.

At the same time, an in-depth study of specific issues concerning the interaction of gender aspects, public internal financial control, particularly risks, and their impact on the functioning of public sector institutions during the budgeting process has been explored in the scientific works of the

following Ukrainian scholars: V. Bazylevych, L. Balastryk, A. Vatuliiov, O. Holynska, I. Hrytsai, T. Koliada, A. Krysovatyi, I. Lopushynskiy, I. Liutyi, L. Nalyvaiko, O. Rozhko, T. Fesenko, and others.

Methods

When studying the gender aspects of the risks of the budget process, the basic general scientific and special methods were used as methods, which are aimed at solving specific scientific problems. In particular, the method of analysis, the method of synthesis, and the method of analogy were used. The use of the analysis method made it possible to consider the budget process through the prism of its constituent parts and analyze the impact of gender risks at each of its stages. The synthesis method, on the contrary, allowed for combining the constituent parts of the object under study, namely the budget process as a whole, taking into account the implementation of gender-oriented budgeting, and to see a holistic picture of the impact of not taking into account gender aspects on the results of the activities of public sector institutions during the budget process. The analogy method made it possible to obtain information on the forecast of the impact of not taking into account gender aspects on the efficiency of the use of budget funds and other state financial resources. During the study, other methods were used, in particular: comparison, concretization, typology, statistical data analysis, expert evaluation, etc.

Results

To ensure social justice, equal satisfaction of the needs and interests of all members of society, regardless of gender, in all political, economic, and social spheres, today it has become important to use the most effective and efficient means and practices of gender budgeting. Such a means can be the application of a gender approach at all stages of the budget process. This will create conditions for identifying existing gender problems, gaps, and discrimination in society, which in turn will allow more effective planning of budgets of business entities, taking into account the identified problems and related risks. The implementation of these measures will ensure more effective use of both human resources and budget funds, which will contribute to the growth of gender equality in all spheres of political, economic, and social development of the state as a whole, and to improve the standard of living of each citizen, recipient/user of public services. Equality is achieved when the decision-making process is aware of the different needs, characteristics, and priorities of men and women (Galizzi, Bassani, & Cattaneo, 2018).

An important nuance is that when applying the gender approach, budget expenditures will be directed to specific target groups, which will contribute to more efficient use of public funds and resources without additional increases in budget allocations, in particular "gender budgeting ... proposed as one of the possible tools for overcoming inequality and the gender gap, starting in the 1980s, and then more widely in the 1990s and in the new century. However, gender budgeting and, more generally, gender-oriented policies are undoubtedly not fundamental. Gender inequality remains embedded in our societies and in public policies. For example, while some advances have been made in addressing gender gaps, the pay gap remains significant..." (Steccolini, 2019).

Nowadays, there is a legislative framework which facilitates the promotion of gender equality in Ukraine (including through budgetary mechanisms), but it needs to be updated with new documents on this issue (Karpynch, & Miedviedkova, 2021).

The issue of gender aspects in the budget process in Ukrainian legislation is currently regulated by various legislative acts: laws, strategies, various plans, programs and other documents and has the following legislative basis:

- Constitution of Ukraine (Verkhovna Rada of Ukraine, 1996);
- Budget Code of Ukraine dated July 8, 2010 № 2456-VI (Budget Code of Ukraine, 2010);
- Council of Europe Convention on Preventing and Combating Violence against Women and Domestic Violence (Istanbul Convention) Date of commission: May 11, 2011; Date of ratification by Ukraine: June 20, 2022; Date of entry into force for Ukraine: November 1, 2022 (Verkhovna Rada of Ukraine, 2022a);
- Law of Ukraine of September 8, 2005 № 2866-IV "On Ensuring Equal Rights and Opportunities for Women and Men" (Verkhovna Rada of Ukraine, 2005);
- Law of Ukraine of June 20, 2022 № 2319-IX "On Ratification of the Council of Europe Convention on Preventing and Combating Violence against Women and Domestic Violence" (Verkhovna Rada of Ukraine, 2022b);
- Order of the Cabinet of Ministers of Ukraine dated February 8, 2017 № 142-r "On approval of the Strategy for reforming the public finance management system for 2017-2020" (Cabinet of Ministers of Ukraine, 2017);
- Order of the Cabinet of Ministers of Ukraine dated December 29, 2021 № 1805-r "On approval of the Strategy for reforming the public finance management system for 2022-2025 and the plan of measures for its implementation" (Cabinet of Ministers of Ukraine, 2021a);
- Order of the Cabinet of Ministers of Ukraine dated June 24, 2016 № 474-r "Some issues of reforming public administration of Ukraine" (Cabinet of Ministers of Ukraine, 2016);
- Order of the Cabinet of Ministers of Ukraine dated July 21, 2021 № 831-r "Some issues of reforming the state administration of Ukraine" (Cabinet of Ministers of Ukraine, 2021b);
- Order of the Cabinet of Ministers of Ukraine dated March 18, 2024 № 244-r "On Approval of the Plan of Ukraine" (Cabinet of Ministers of Ukraine, 2024b);
- Order of the Ministry of Finance of Ukraine dated January 2, 2019 № 1 "On Approval of Methodological Recommendations for the Implementation and Application of a Gender-Oriented Approach in the Budget Process" (Ministry of Finance of Ukraine, 2019a);
- Order of the Ministry of Finance of Ukraine dated December 10, 2010 № 1536 "On effective indicators of the budget program" (Ministry of Finance of Ukraine, 2010);
- Order of the Ministry of Finance of Ukraine dated May 19, 2020 № 223 "On the assessment of the effectiveness of budget programs of the state budget" (Ministry of Finance of Ukraine, 2020);
- Order of the Ministry of Finance of Ukraine dated October 23, 2019 № 466 "On reviews of state budget expenditures", etc. (Ministry of Finance of Ukraine, 2019b).

The issue of gender aspects in the budget process in Ukrainian legislation is currently regulated by various legislative acts: laws, strategies, various plans, programs, and other documents.

The legislators emphasize that the need to introduce the concept of "gender" in budget legislation is aimed at emphasizing its economic importance, associated with the influence of not always well-regulated stereotypes of behavior, which are caused by certain "incorrect" generally established social roles of women and men in social life, and can lead to certain economic consequences:

- Strengthening of established gender stereotypes, in terms of not taking into account the specific needs of women and men when planning the budgets of business entities;

- Reducing women's equal access to the use of certain resources;

- The formation of economic inequality in terms of the unfair distribution of wages between women and men;

- The emergence of risks of inefficient use of budget resources, etc.

The study of the national legislation of Ukraine showed that the main idea of gender equality, in particular the provision on ensuring equal rights and opportunities for Ukrainian citizens, is laid down in certain principles of the functioning of the budget system of Ukraine, which is fundamental for the implementation of the gender approach in the budget process.

It should be noted that the Budget Code of Ukraine enshrines the principle of efficiency and effectiveness of the budget system of Ukraine, according to which, when drawing up and implementing budgets, all participants in the budget process should strive to achieve the goals planned based on the national system of values and tasks of innovative economic development by ensuring the quality provision of public services, including taking into account gender aspects, while attracting the minimum amount of budget funds and achieving the maximum result when using the amount of funds determined by the budget (Budget Code of Ukraine, 2010).

First of all, the term "gender" is not clearly defined in the normative and legislative documents of Ukraine, but its meaning is enshrined in the Istanbul Convention. In this document, the definition of "gender" is indicated as socially fixed roles, behavior, activities, and characteristics that a certain society considers appropriate for women and men (Vyhovska et al., 2024).

As for the history of the emergence of gender budgeting as such, as noted by T. Polser, in his article, practitioners initiated government steps towards gender budgeting, with Australian feminists popularizing gender budgeting in the early 1980s, leading to the first implementation of the Women's Budgeting Program in 1984 (Polzer, Nolte, & Seiwald, 2023).

In general, the concept of "gender" has several main aspects, but we will consider an economic construct where taking into account the gender aspect in budget planning allows for effective and fair distribution of resources in accordance with the actual needs of women and men, while minimizing the risks of the budget process and not increasing the budget allocations planned for the institution. A principal aim of GB has been to integrate gender analysis into macroeconomic policy, government spending, and revenue proposals with a view of ensuring they promote gender equality (Elomäki, & Ylöstalo, 2021).

The need to make management decisions authorized by officials of state bodies to implement a set of measures to take into account gender aspects at all stages of the budget process is closely related to the timely identification and assessment of the impact of possible risks that arise during the implementation of such activities.

So, Rozhko emphasizes that budget risk management should be carried out on the basis of compliance with a set of principles, in particular: totality, integration, efficiency, dynamism, and permissible level of risk (Rozhko, 2016).

According to Liutyi at the stage of preparation and drafting of the budget, the quality of the budget process at its various stages can be influenced by the following factors

or risk-generating elements: political interests of government structures, dependence on the adoption of other related decisions (such as the tax package), the reliability of the information base and scientific methodologies, the professional level of project development, and the interests and requirements of international financial and credit institutions, among others (Liutyi et al., 2023).

At the stage of consideration and approval of the Law on the State Budget of Ukraine for the respective year, influencing factors may include the direction of interests of certain government structures, groups, or individuals (interest lobbying), as well as the level of awareness, responsibility, and competence of members of parliament regarding economic and budgetary issues.

At the stage of budget execution, the key factors are compliance with the provisions of the Law on the State Budget of Ukraine for the respective year and other regulatory acts, as well as the presence of an effective system of operational budget control (Liutyi et al., 2023).

Ukraine's budget legislation is aimed at integrating the gender aspect into the planning of budgets at all levels.

In accordance with the Methodological Recommendations for the implementation and application of a gender-oriented approach in the budget process, the gender-oriented approach is the consideration of gender aspects at all stages of the budget process and highlighting in the relevant budget documents the focus on ensuring equal rights and opportunities for women and men (gender equality) (Ministry of Finance of Ukraine, 2019a). In these methodological recommendations, the specified process received an abbreviated name - GOB (Gender Responsive Budgeting (GRB)) and has established itself as an effective management tool and an effective tool for effective budget planning.

Domestic scientists emphasize in their research that gender budgeting is one of the most important tools and financial stabilizers for ensuring security and development of gender equality in all spheres of the country's economy and in the country's defense sector in order to protect human rights (Vyhovska et al., 2024).

The process of gender budgeting includes the following main elements:

- Implementation of gender analysis;
- Adoption of appropriate changes in the programs and budgets of state bodies;
- Continuous implementation of gender budgeting in the budget process.

GRB is a process in which the needs and interests of women and men are taken into account based on gender equality at the stage of developing programs, projects, and policies at all levels and stages of the management decision-making process. In the understanding of the budget process, namely minimizing the risks of the budget process, an example can be the consideration of the gender component, in particular, ensuring the representation of all beneficiaries in the process of making management decisions for equal access to the distribution of budget funds for their effective and efficient spending at all stages of the budget process. As many governments enact policies to address social inequities, a significant gap remains between approving reforms and seeing actual results. Our study of GRB (Gender-responsive budgeting) in Ecuador shows that even a celebrated reform that from the outside seems relatively successful can have a long road ahead to exert significant changes to policy making and accountability (Guzmán, 2024).

The second paragraph of the second point of the second part of the Section III of the Resolution of the Cabinet of Ministers of Ukraine No. 142-r dated February 8, 2017, "On Approval of the Strategy for Reforming the Public Finance Management System for 2017–2020," states that integration of a gender-oriented approach into the budget process will ensure an increase in the efficiency and quality of public services provided, taking into account the needs of social groups, including on the basis of gender, and will strengthen the accountability of budget managers and budget transparency. At the same time, an effective assessment of performance indicators should be ensured in order to make timely management decisions aimed at adjusting the

activities of the budgetary institution to achieve the goals (Cabinet of Ministers of Ukraine, 2017).

Since the implementation of GRB requires state institutions to take into account the gender needs of all beneficiaries, it is necessary to improve existing models of budget planning and use of budget resources, conduct a detailed analysis of the effectiveness of budget programs, as well as improve the budget risk management system in terms of taking into account gender aspects at all stages of the budget process.

For clarity, we give examples and consequences of the impact of risks in Table 1 in accordance with the stages of the budget process.

Table 1

Gender aspects of risks at different stages of the budget process

№	Stages of the budget process	Possible risks (gender aspect) and the possible consequences of their impact
1.	Preparation and review of the Budget Declaration (local budget forecast)	The risk of not taking gender aspects into account when formulating budget indicators in the Medium-Term Budget Declaration, ignoring gender goals and indicators for their achievement. Consequences of influence: inefficient use of public funds (with potential losses of budget allocations due to suboptimal distribution), further deepening of gender inequality (in areas where women account for more than 60% of social program beneficiaries), loss of opportunities to improve the lives of various population groups (e.g., internally displaced persons), and slowdown in economic recovery, etc.
2.	Preparation of draft budgets	Risk of failure to take into account comments and proposals on gender aspects based on the results of gender analysis of budget programs in draft budgets (e.g., failure to take gender aspects into account in program budgeting). Consequences of influence: inefficient use of public funds and decline in the quality of public services (redistribution of resources and underinvestment in sectors where there is an urgent need), decline in the quality of public services, increased social vulnerability (women in rural areas or occupied territories where access to services is limited by war), accumulation of financial irregularities that complicate the task of maintaining the stability of the state budget in the medium term, etc.
3.	Consideration of the draft and adoption of the law on the State Budget of Ukraine (decision on the local budget)	Risk of not including information on overcoming gender gaps in budget programs and/or risk of not including such programs in the draft law on the State Budget of Ukraine (annually). Consequences of influence: inefficient use of public funds (losses in social spending), slowdown in the country's economic development (due to underestimation of women's contribution to GDP, estimated at 40% according to World Bank data, due to limited access to the labor market for various reasons and discriminatory barriers), exacerbation of structural inequalities in terms of the impact of budgetary decisions on women and men and/or their groups due to existing socio-economic and institutional inequalities (e.g., in employment, where there is a gender pay gap), against the backdrop of these problems, increased political risks (decreased donor confidence and, as a result, decreased external financing), etc.
4.	Execution of the budget, including amendments to the Law on the State Budget of Ukraine	The risk of not including the gender component in the characteristics of budget programs at the stage of drawing up budget program passports. Consequences of influence: incorrect prioritization of budget programs (negative impact on various social groups, disregard for strategic goals and objectives, etc.), reduced efficiency and effectiveness of budget expenditures due to the mismatch between priorities and the real socio-economic needs of the population, complications in monitoring and assessing the impact of budget programs on different gender groups, which complicates the timely adjustment of budget policy for the effective use of public funds and resources, etc.
5.	Preparation and review of the budget implementation report	Risk of not including information on the inclusion of gender aspects and their actual implementation (based on the results of monitoring and evaluation of effectiveness) in the report on the implementation of the budget program passport. Consequences of influence: lack of objective information on assessing the degree of gender equality in budget programs and the possibility of eliminating gender imbalances in the distribution of budget funds when planning the budget for subsequent periods, lack of transparency and accountability in the budget process, insufficient justification of management decisions to adjust budget policy to increase the efficiency of public spending and promote greater social equality in public finances, etc.

Source: developed by the authors.

Gender budgeting involves restructuring income and expenditure in such a way that the needs of society, both women and men, are represented in budget articles. Gender-based budget analysis can be taken into account in a wider range of issues. Their solution would be to create equal opportunities for members of society and ensure its sustainable development. This approach makes the budget more efficient, fair, and transparent (Horodetska, 2017).

It should be noted that the GRB needs some improved legislative support on risk management of the budget process, further improvement and development of the regulatory framework, clarification of existing norms, explanatory work with the staff of state bodies on understanding the need to introduce GRB approaches, improve the national methodology for integrating a gender-oriented approach into budgeting, continue to implement a set of measures to develop a system of indicators for gender

analysis of budgets, both at the planning stage and at the stage of budget implementation by state authorities to take into account gender aspects in all spheres of public administration, etc.

To solve these problems, international partners can be involved and an analysis of the best foreign practices can be carried out regarding the successful implementation of a gender-oriented approach at various stages of the budget process, which will make it possible to outline priority tasks: the first task may be to strengthen political support for gender initiatives, which will allow to adjust the development programs of various sectors of the economy taking into account the gender aspect and, as a result, to improve the efficiency of public finance management, improve the overall economic and social situation in the country. There is also a need to coordinate the efforts of various departments to solve the issues of transition to a gender-oriented approach to budgeting (Medvedkova, 2021).

At the same time, considerable attention should be paid to the further practical application of the gender-oriented approach in the budget process at the state and local levels to ensure that the needs of social groups, including on a gender basis, are taken into account, in particular, to strengthen the accountability of the main managers of budget funds and to increase the transparency of budgets in these areas (Verkhovna Rada of Ukraine, 2005).

In the activities of public sector institutions, the gender approach is implemented through certain sequential steps: conducting a gender analysis of the institution's activities, developing a program based on the results of gender analysis, the stage of allocating resources for the implementation of the planned program taking into account gender aspects, the actual implementation of the program and the last step - monitoring and evaluating the

effectiveness of the implemented solutions, from the point of view of analysis for more effective planning and minimization of budget risks (gender aspect) in further activities. Implement a system for monitoring and evaluating the effectiveness of gender budgeting, which will allow monitoring progress and making adjustments to budget programs in order to increase gender sensitivity. The final result of gender budgeting is the achievement of gender equality in the development of public infrastructure and the social sphere (Marukhlenko et al., 2024).

The national legislation defines a unified methodology and criteria for conducting a gender audit by business entities. Gender audit includes an assessment of the current state of ensuring equality and the implementation of a comprehensive gender approach in the activities of state bodies, in particular: the formation of working groups to conduct a gender audit, the organization and conduct of surveys/focus groups, the analysis of internal regulatory documents, reporting on gender balance in personnel policy, fair distribution of budget funds and other financial resources, etc. Based on the results of the gender audit, a report is drawn up with recommendations for solving the identified problems and ways to overcome them.

Data on the distribution of employees of the State Bureau of Investigation by gender during 2020–2024, presented in Fig. 1.

For this study, statistical data obtained from open sources of law enforcement agencies of Ukraine, in particular, the State Bureau of Investigation (hereinafter referred to as the SBI) and the Office of the Prosecutor General (hereinafter referred to as OPG), were used. This information is publicly available and does not require special permissions for use.

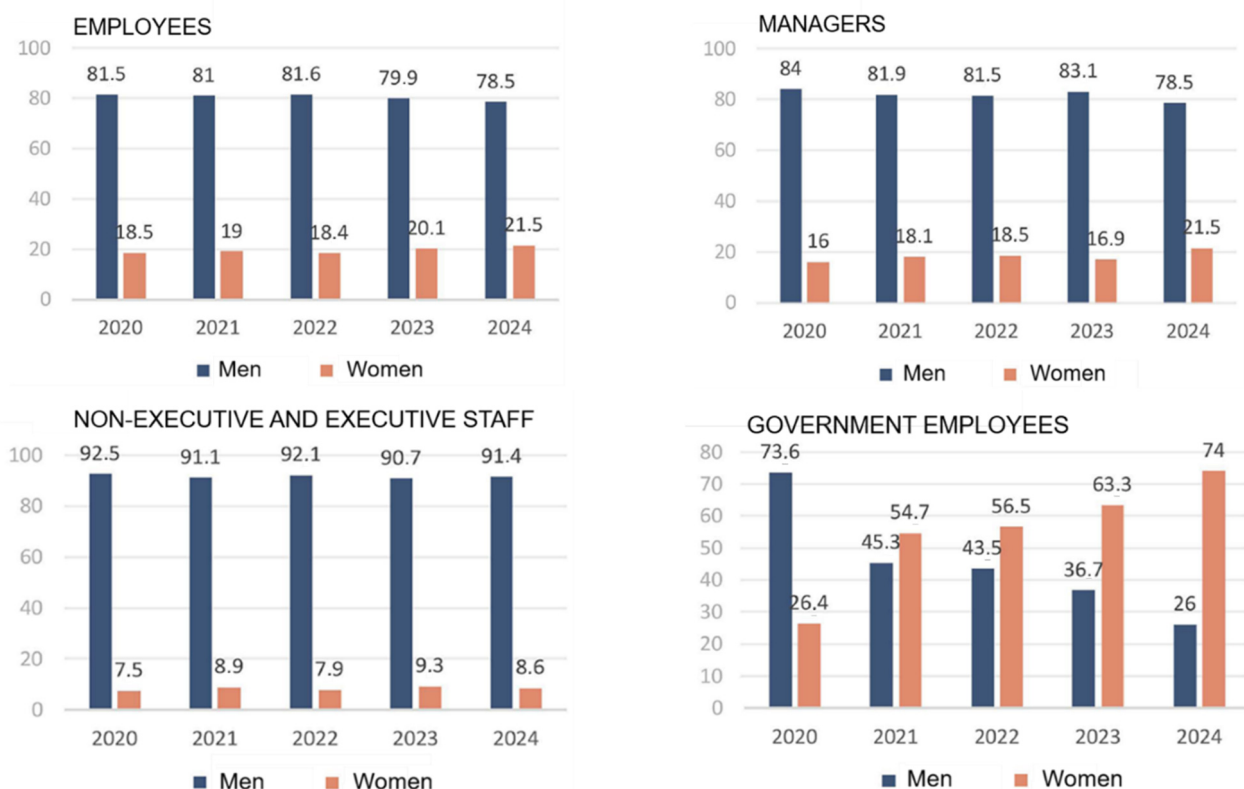


Fig. 1. Distribution of employees of the State Bureau of Investigation by gender, 2020–2024

Source: <https://dbr.gov.ua>.

Figure 1 shows that the share of women among employees during 2020–2024 remains relatively stable, at the level of about 20%. And the graph with the representation of women leaders relative to male leaders shows a slight upward trajectory. In 2024, this figure was 21.5% compared to 16% in 2020, which is definitely a positive trend, but still far from parity (50%). The reasons for restrained growth against the background of reforming the public administration sector, with the support of gender balance in personnel policy, may be the security factor and the outflow of personnel due to the war in Ukraine from 2022 to the present.

However, the dynamics in the civil service are the opposite: in 2024, the share of women was 74%, compared to 26.4% in 2020. These statistics may indicate a gradual improvement in the gender balance of management personnel, but it is necessary to investigate more deeply the problem of the sustainability of the proportion of women among the total number of employees in order to identify and solve the problem or mitigate the risks that may accompany this process. Gender-diverse personnel demonstrate 20–30% higher productivity and effectiveness.

The increase in the proportion of women will be consistent with the principles of gender equality enshrined in the Comprehensive Strategic Plan for Law Enforcement Reform as Part of the Security and Defence Sector of Ukraine for 2023–2027, approved by the Decree of the President of Ukraine dated May 11, 2023 № 273/2023 (Decree of the President of Ukraine, 2023), the Action Plan aimed at the implementation of the Comprehensive Strategic Plan for the Reform of Law Enforcement Bodies as part of the security and Defence Sector of Ukraine for 2023–2027, approved by the Order of the Cabinet of Ministers of Ukraine dated August 23, 2024 № 792-r (Cabinet of Ministers of Ukraine, 2024a) and the implementation of the State Strategy for Ensuring Equal Rights and Opportunities for women and Men for the period up to 2030, approved by the Order of the Cabinet of Ministers of Ukraine dated May 2, 2025 № 439-r (Cabinet of Ministers of Ukraine, 2025).

The main results showed that a high share of women in the local representative body positively affects the level of local government BT (Budget Transparency). We also find that women are more transparent when it comes to both mandatory and voluntary elements of OLBT (Open Local Budget Transparency) (Stanić, 2023).

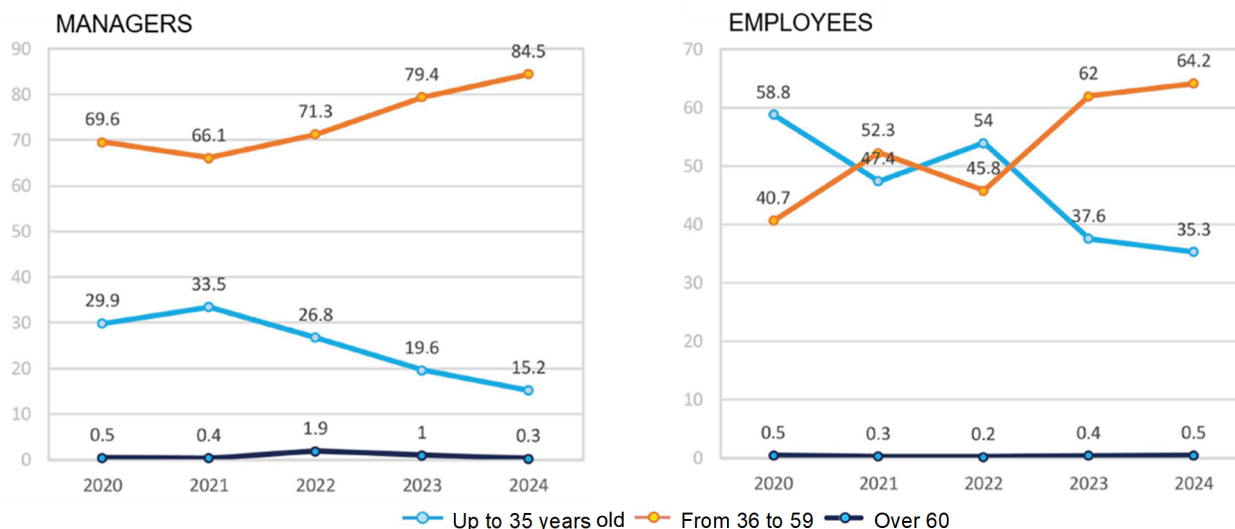


Fig. 2. Distribution of employees SBI by age groups for 2020–2024, %

Source: <https://dbr.gov.ua>.

Analyzing Fig. 2, where the age distribution of employees is presented with a distinction by gender, we can see that the age group up to 35 years has been steadily decreasing in recent years, but there is a steady increase in the age category of 36–59 years from 2021 to now, which may indicate an outflow of young personnel in connection with the war and an acute personnel crisis, which increases the risks of the budget process and weakens budget sustainability. To stabilize the situation, further monitoring and analysis of the situation may be recommended with the preparation of recommendations to encourage young people to work in the public sector, in particular law enforcement agencies, through financial incentives, the introduction of a program aimed at developing skills/training (training) of personnel, the implementation of quotas for young people in state bodies, etc.

The issue of integrating the GRB into the entire budget cycle, namely in all its stages, remains relevant: drafting and consideration, drafting budgets, consideration of the draft budget, and annual adoption of the law on the State Budget

of Ukraine for the next year, budget implementation, preparation, and consideration of the report on budget implementation. It should also be remembered that at all stages of the budget process, control over compliance with budget legislation, audit, and evaluation of the effectiveness of budget management in accordance with the legislation are carried out (Budget Code of Ukraine, 2019). At all stages of the activities of the participants in the budget process (bodies and institutions), officials vested with budgetary powers (rights and obligations to manage budget funds) should clearly understand the importance of implementing the GRB and, depending on the stage of the budget cycle, analyze and assess the impact of budget decisions on taking into account gender needs and achieving gender equality, as well as predicting the gender consequences of state budget expenditures (allocations for programs aimed at meeting gender needs, spending on gender-sensitive public services, etc.), implementing fiscal policy and relevant programs.

The GRB is designed to promote transparency and efficiency of budget planning, counter embezzlement and

corruption in all branches of government at all levels, equal involvement of women and men in budget planning, guarantee the distribution of budget allocations in accordance with gender equality, promote economic development by reducing gender gaps, and ensure gender equality etc. At the same time, gender budgeting requires the political will, appropriate resources, and technical capabilities of civil servants, civil society actors, and other development partners. Its success depends on the degree of institutionalization and whether there is enough political will to structurally introduce gender budgeting as one of the foundations of fiscal policy (Cheberiako, & Hnatiuk, 2020).

Every year, the Ministry of Finance of Ukraine analyzes the consideration of gender aspects during the formation of budget indicators, which are provided by the main managers of state budget funds as part of the preparation of proposals for the Budget Declaration for the medium-term period.

When forming the budget program, the main managers of the state budget funds should take into account the results of the gender analysis of the budget program and include certain gender aspects in all or some of the characteristics of the budget program. In this case, the performance indicators should include quantitative and qualitative values that characterize the focus of the budget program on ensuring the principles of gender equality in accordance with the defined goals, objectives, and directions of the use of budget funds.

We would like to note that the mechanism of implementing GRB into the budget process is somewhat similar to the process of identifying and assessing the risks of the budget process.

The sequence of application of a gender-oriented approach in the budget process includes several stages:

- I. Review of regulatory legal acts and other legal documents on gender aspects;
- II. Conducting gender analysis of budget programs;
- III. Decision-making based on the results of the gender analysis of budget programs;
- IV. Monitoring the effectiveness of gender-sensitive budget programs.

Thus, at the I stage of the implementation of the GRB, it is advisable to review the regulatory legal acts and other legal documents that may contain information on gender equality and the status of implementation of these provisions: current national legislation, international agreements, directives of international organizations, which include Ukraine, as well as reports and reports of international organizations, scientific institutions and public associations, etc. In the process of conducting gender analysis of budget programs and making management decisions, information on gender equality is generalized according to the following criteria:

- Indicators of gender equality defined by international agreements (requirements or indicators), directives of international organizations of which Ukraine is a member;
- Indicators of gender equality are defined by the current national legislation;
- Data on the situation of women and men (their groups);
- Data on the interests, needs, and priorities of women and men (their groups);
- Data on gender gaps, gender discrimination, trends in meeting the needs and interests of women, men (their groups).

If necessary, responsible performers for the implementation of the GRB can be identified at this stage. For example, working groups have been created or gender advisers have been identified.

At the II stage, the managers of budget funds, represented by the responsible performers, carry out a gender analysis of budget programs: they indicate gender aspects, identified features, decisions taken and measures taken to take into account the gender aspect in the budget program under study to identify gender gaps, gender discrimination and the reasons for their occurrence in the process of implementing the budget program.

Every year, the main managers of budget funds report to the Ministry of Finance of Ukraine on the results of the gender analysis of the budget program and consideration of gender aspects in accordance with the specified reporting forms, which indicate:

- A list of normative legal acts, namely the provisions and their status of implementation;
- Results of the study of the budget program: analysis of gender aspects, identified features, decisions made based on the results of the analysis, and measures taken;
- A detailed description of the gender aspect in the characteristics of the budget program: goal, task, directions of use of budget funds, and performance indicators, etc.

To ensure the completeness of the gender analysis of budget programs, a wide range of data is used, in particular: quantitative and qualitative indicators disaggregated by article from official statistics, financial and budget statements of the business entity, accounting data, as well as strategic planning documents, reports on the implementation of budgets, regulatory legal acts and other sources that may contain information on the gender distribution of public resources and the results of the implementation of budget programs in terms of the implementation of the gender component.

The result of this stage is the results of the analysis of data and other information that has been studied to take into account gender aspects, identify gender gaps and discrimination, ensuring equal distribution of budget funds to meet the needs and interests of both women and men. Based on the results of the analysis of the identified problems, the next step is to prepare proposals for their solution, while special attention is paid to the development of clearer criteria for gender sensitivity for budget programs, further integration of gender indicators into the relevant budget reporting, and, as a result, ensuring equal access of women and men to public financial resources.

At the third stage, decisions are made based on the results of gender analysis of budget programs. Decisions are made by the main managers of budget funds and other participants in the budget process in accordance with the assigned tasks and competencies, taking into account the proven budget allocations.

Based on the results of the management decisions taken at the IV stage, the effectiveness of the implementation of gender-sensitive budget programs is monitored, and budget programs are planned for future periods with the inclusion of gender needs not taken into account in the current period, as well as the establishment of new gender-sensitive goals and indicators.

Cooperation between Ukraine and the EU in the field of gender budgeting plays a key role in supporting and developing gender equality in Ukraine. Thus, the exchange of best practices and the introduction of innovative approaches to budget planning are the basis of international cooperation. ... The factor of international cooperation is the development and implementation of training programs aimed at increasing the awareness and qualifications of civil servants. Strengthening the role of local authorities and the

public in gender budgeting should correspond to budgeting projects. The efforts made create an inclusive financial environment in which decisions are made taking into account the gender perspective (Marukhlenko et al., 2024).

The legislation regulates the methodology and organization of assessing the effectiveness of budget programs by the main managers of budget funds at all stages of the budget process for targeted, effective, and efficient use of budget funds. Sources of information, among other things, are the results of gender analysis of budget programs (Ministry of Finance of Ukraine, 2020).

Attention should also be paid to the general requirements for planning, implementation, and reporting on the implementation of the budget program by the main managers of budget funds (Ministry of Finance of Ukraine, 2010). Among other things, performance indicators should meet such requirements as the degree of ensuring equal rights and opportunities for women and men and/or their groups. The following groups of performance indicators are distinguished, in particular:

- Cost indicators;
- Product indicators;
- Performance indicators;
- Quality indicators.

The list of effective indicators is determined by the main manager of budget funds, taking into account the specifics of the budget program. All data that will be used to prepare performance indicators must be confirmed, substantiated by official documents and reliable sources, and be easy to understand by the general public.

It should be emphasized that the sphere of law enforcement constitutes a multifaceted system in which the evaluation of institutional effectiveness and achieved outcomes represents a complex and specialized process. This process is manifested through a combination of quantitative and qualitative performance indicators that correspond to the statutory functions of a given state body. The general criteria for such indicators encompass the degree of compliance with legal norms, the level of professional competence among personnel, the assurance of equal rights and opportunities for both employees of state institutions and service recipients, the degree of public trust, the efficiency of state financial resource utilization in attaining objectives, and the effectiveness of interagency cooperation within the law enforcement sector.

As part of the subject of our research, we will analyze the information given in Table 2 regarding the results of the work of investigators of the State Bureau of Investigation for the period from 2019 to 2024.

Table 2

Statistical information on the results of the work of investigators of the State Bureau of Investigations 2019–2024

INDICATOR	2019	2020	2021	2022	2023	2024
Number of women who are victims of criminal offenses registered by investigators of the State Bureau of Investigations	459	395	181	200	181	124
Number of criminal offenses in which suspicion has been reported, where the victims are women	48	95	73	108	129	92
Number of indictments sent to court where women are victims	55	123	94	95	129	80
The number of criminal offenses in which women have been notified of suspicion	84	138	111	230	320	393

Source: <https://dbr.gov.ua>.

The data reflect a steady decrease in the number of women who have become victims of criminal offenses (from 459 in 2019 to 124 in 2024), while there has been an increase in the number of criminal offenses in which suspicions have been reported, where the victims are women (from 48 in 2019 to 92 in 2024, with a peak in 2023 at the level of 129 suspicion) and the number of indictments sent to the court where the victims are women (from 55 in 2019 to 80 in 2024, with a peak in 2023 at the level of 129 indictments). This indicates an improvement in the detection of cases of gender-based violence by employees of the State Bureau of Investigation. Instead, the number of criminal offenses in which women were notified of suspicion increased significantly (from 84 in 2019 to 393 in 2024). This situation indicates a deterioration in the standard of living of the population and may indicate economic factors of crime. We see a positive result between the introduction of gender-sensitive budgeting and the increase in spending on training and reintegration of women, who are notified of suspicion, which will reduce the risks of cases of recidivism and the corresponding financial burden on the budget.

For example, let's consider the information of the Prosecutor General's Office in terms of taking into account gender aspects in the preparation of effective indicators of the department's activities, in particular regarding the composition of persons who committed criminal offenses in January 2025 (Table 3).

The data set for analysis contains information about 65,939 people who were notified of suspicion of criminal

offenses, which are effective indicators of the activities of the Prosecutor General's Office. From the point of view of the gender aspect, the analysis of these indicators reveals certain risks due to unaccounted for gender inequalities, namely: out of 57,983 identified offenders, women account for 7,217 people, 12.4%. However, the indicator of the number of female offenders is excessively represented among those who committed an offense against children (284 female offenders out of a total of 1,757 offenses against children, 16.2%). This may indicate gender-based pathways to crime, such as intra-family dynamics. The age distribution also reveals certain patterns and indicates economic factors, in particular, the cause may be the war in Ukraine, namely, the occurrence of economic stress caused by the conditions of displacement. Female offenders predominate in the age groups: 29-39 (2,405 offenses) and 40-54 (2,293 offenses), respectively.

Another risk factor is the patterns of victimization (processes or conditions that turn a person into a victim as a result of a criminal encroachment) that emphasize the risks of gender-based violence. This category includes offenses related to domestic violence, namely: 4,150 people who committed criminal offenses were identified. Offences in this category against women total – 11,931, and children – 1,757, and have a pronounced gender specificity and emphasize the fact that unremoved gender-based violence can create conditional obligations for budgets in terms of increased health care costs, lost productivity, and, as a consequence, an increase in social spending.

Table 3

Composition of individuals convicted of criminal offenses

Indicators		Total persons	Including those who have committed criminal offenses					
			Related to domestic violence	Concerning women	Regarding children	Minors	Women	Participants in the Anti-Terrorist Operation, Joint Forces Operation, and combat operations related to the Russian Federation's aggression against Ukraine
Number of persons notified of suspicion		65939	4314	12540	1830	949	8278	2673
Number of persons subject to special pre-trial investigation		232	0	0	0	0	64	4
Number of persons in respect of whom criminal proceedings have been closed on rehabilitative grounds		3	1	1	0	0	0	0
Number of persons in respect of whom criminal proceedings have been closed based on paragraph 10 of part 1 of Article 284 of the Criminal Procedure Code of Ukraine		0	0	0	0	0	0	0
Persons who committed criminal offenses have been identified		57983	4150	11931	1757	947	7217	2415
Including	to whom preventive detention has been applied	4809	183	918	125	60	290	331
characteristics of identified persons who have committed criminal offenses	by age at the time of committing a criminal offense	up to 14 years old	78	0	25	31	78	17
		14-15 years old	260	4	82	88	260	38
		16-17 years old	609	12	131	122	609	65
		18-28 years old	12587	460	1979	453	0	1400
		29-39 years old	19834	1300	3731	496	0	2405
		40-54 years old	18525	1660	4120	429	0	2293
		55-59 years old	2752	291	761	59	0	436
		60 years and older	3338	423	1102	79	0	563
	women	7217	432	2205	284	120	7217	14
	by education at the time of committing a criminal offense	higher and pre-higher professional education	8045	269	1224	202	4	1586
		vocational (vocational and technical)	10482	833	2205	381	14	1026
		basic, secondary, and specialized secondary	38798	3017	8329	1075	673	4502
		initial	500	26	126	87	235	73
		uneducated	158	5	47	12	21	30
	citizenship at the time of committing a criminal offense	citizens of Ukraine	57553	4131	11839	1752	947	7183
		foreign nationals	389	18	85	5	0	29
		stateless persons	41	1	7	0	0	5
		illegal immigrants	4	0	0	0	0	0
		refugees	6	0	0	0	0	2

Source: <https://gp.gov.ua>.

Social characteristics that indicate socio-economic factors and indicate gender-differentiated access to education as a risk factor for an increase in the crime rate cannot be ignored. Offenders with basic secondary and specialized secondary education dominate (38,798 people), including 4,592 women, while persons with higher education are less represented in this category and make up 8,045 people, of which 1,586 are women.

According to the authors, the analyzed data support the idea that the use of gender-oriented budgeting in law enforcement agencies can help reduce gender-based patterns of crime by planning targeted expenditures and, as a result, reducing the risks of uncertainty of additional costs in the implementation of budgets.

The comprehensive strategic plan for reforming law enforcement agencies as part of the security and defense sector of Ukraine for 2023–2027 provides for the reform of the management system, which will be result-oriented in accordance with the established priorities, in particular:

improvement of internal control mechanisms as a tool for ensuring budget discipline, which will contribute to reducing the risks of the budget process, increasing accountability and transparency of costs, integrating the principles of gender equality in personnel policy, compliance with the principles of inclusion and definition of key performance indicators (KPI). Each budget institution, taking into account its functions and main tasks, as well as the actual level of internal control on a certain date, forms its own internal control system (Melnik et al., 2024).

Thus, taking into account all of the above, the authors of this study propose a step-by-step algorithm for taking into account gender aspects when assessing the risks of the budget process to integrate a gender-oriented approach, including when forming the characteristics of budget programs that are included in the budget documents drawn up by the main managers in accordance with the forms established by the Ministry of Finance of Ukraine at various stages of the budget process, presented in Fig. 3.

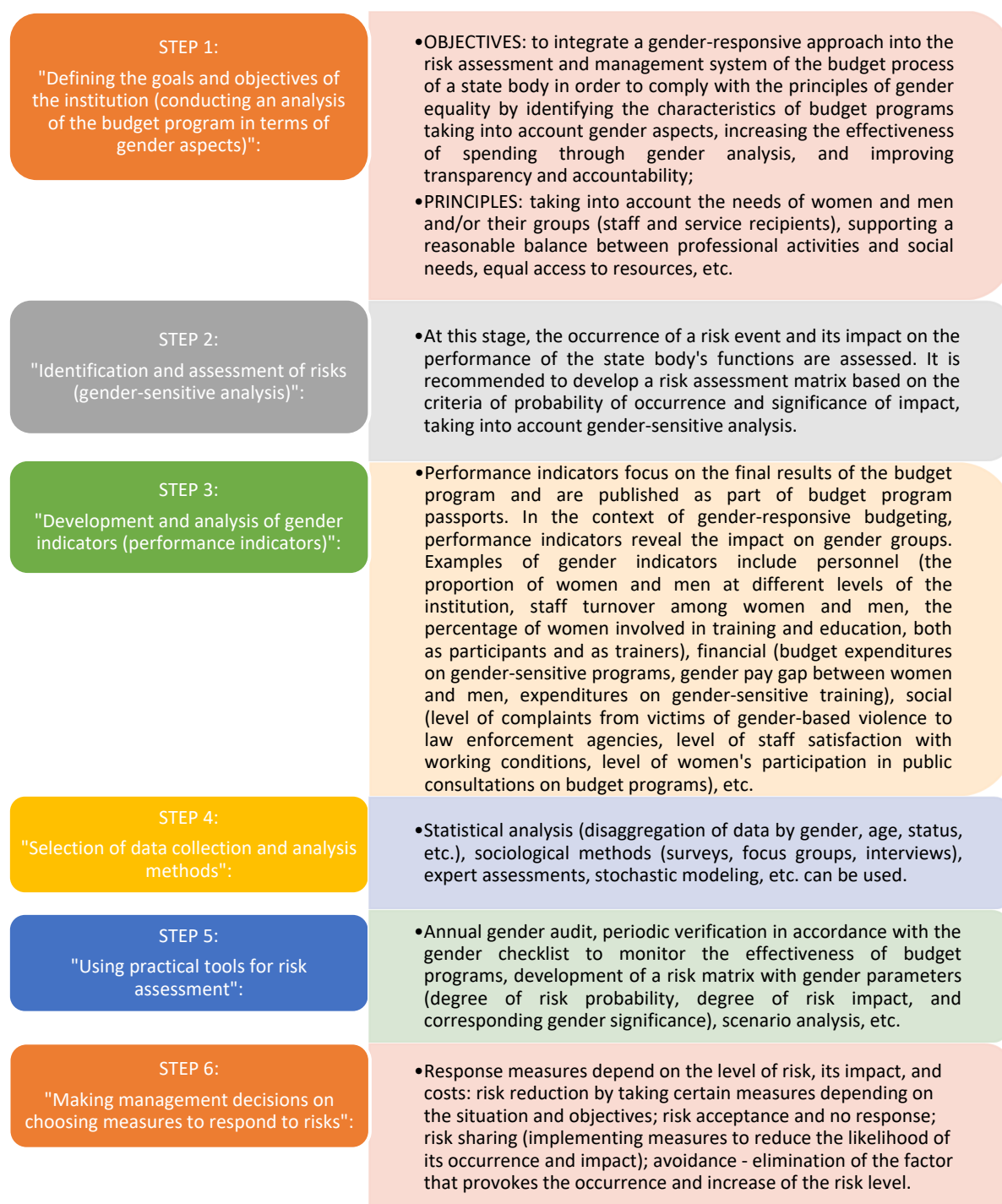


Fig. 3. Algorithm for taking gender aspects into account when assessing risks in the budget process

Source: developed by the authors.

Therefore, today there are enough "gender problems" in Ukraine, including gender inequality in the labor market, stereotypical ideas about the traditional roles of women and men, low level of representation of women in leadership and politics, difference in wages, discrimination by age, sex, family status, a large number of cases of domestic violence, the negative impact of the war in Ukraine on gender equality, which provoked mass mobilization, emigration, internal displacement of persons, emotional and psychological stress, as well as the lack of systematic introduction of gender initiatives in state policy. All this is reflected in the quality of life of the population.

Although the principles of gender-based budgeting are enshrined in the Budget Code of Ukraine, their implementation remains complex and uneven, depending on the sector of the economy and region of the country. The situation is the same in state bodies – not everyone has the resources and internal instructions for the implementation of gender-oriented budgeting.

A separate problem remains the human resources potential, in particular, the presence of specialists/advisers on gender issues in the institution's staff; respectively, the implementation of gender-oriented budgeting is perceived formally, and not as a tool for strategic management.

Currently, gender aspects are not taken into account when assessing and managing the risks of the budget process. It is difficult to obtain high-quality statistical data, especially in sectors where budget programs are not socially oriented, in particular, the defense sector, law enforcement agencies of Ukraine, etc. The methodology for taking into account gender aspects at all stages of the budget process is insufficiently developed, which is also complicated by the low level of communication between the responsible state bodies. The lack of clear methodology, statistics, and tools for assessing gender impacts makes it difficult to identify and address specific gender issues in different sectors. In addition, the involvement of the public and stakeholders is critical to ensuring transparency in the gender budgeting process. In democratic states, there is a demand for raising awareness of the importance of gender budgeting among officials and the public through information campaigns (Marukhlenko et al., 2024).

However, there are certain prospects for the development of gender-oriented budgeting in Ukraine, in particular: continuation of gender analysis at all stages of the budget process, creation of a unified approach to conduct a gender audit of budget programs to ensure comparability of results. Conducting and developing high-quality training programs and training for employees responsible for gender issues. The integration of the gender dimension into the assessment of budget risks can be a tool to reduce the consequences of ineffective management decisions and minimize their negative impact. GRB (Gender-responsive budgeting) is one instrument towards striving for equality for social groups in public budgeting. The Austrian experience has demonstrated that meaningful application of GRB tools requires complementary implementation activities such as training, quality assurance, and political support in the different forums and genres (Nolte, Polzer, & Seiwald, 2021).

The introduction of gender-oriented budgeting in Ukraine as part of budget management will ensure effective, economical, and efficient use of public financial resources and improve the socio-economic well-being of the population.

Discussion and conclusions

Why is it so important to integrate a gender-oriented approach into all stages of the budget process? This will allow timely and effective identification of the needs of women and men, for their fair consideration when making budget decisions on the management of public finances, to effectively use and distribute budget funds and other public resources, improve the efficiency of budget expenditures, to create a more just society, with equal opportunities for all, that is, reduce inequalities and imbalances, ensure more sustainable and inclusive economic growth, etc.

It is important that when implementing the gender approach in the budget process at all its stages, no additional involvement of budget funds is required, and the optimization of expenditures takes place thanks to the introduction of gender-oriented budgeting. However, this process faces some challenges and risks that may threaten to ensure compliance with the legality and efficiency of the use of budget funds, state property, and other resources, in terms of achieving results by the authorities in accordance with the established goal, objectives, plans, and requirements for the implementation of the functions assigned to them by the current legislation. GRB should be implemented at all levels of the state budget in order to integrate the gender approach, influence fiscal decisions, and assess the effectiveness of public spending on gender sensitivity by analyzing budget programs.

Modern research on this issues shows that the implementation of the gender approach faces certain challenges and risks on its way, in particular: shortcomings in wording and certain gaps in regulatory legal acts, insufficient training of responsible officials on gender aspects and, as a result, formal attitude to the implementation of GRB, weak communication between authorities, lack of gender statistics data, insufficient transparency of budget processes, lack of systematic checks and regular gender audits, etc. To overcome these problems, it is necessary to improve the legislative framework by clarifying the norms on gender aspects and their impact on the budget process; to develop effective gender-sensitive indicators in accordance with the needs of public sector institutions and their specifics of their activities; regularly improve the qualifications of responsible performers involved in the budget process; promote the improvement and establishment of communication between authorities and society; use the best international practices, etc. These measures will contribute to improving the level of transparency and, as a result, the effectiveness of the use of public financial resources.

Therefore, for the effective implementation of gender policy in the system of public administration, it is necessary to apply a comprehensive gender approach at all levels and stages of the budget process, which will allow for effective and efficient use of budget funds and other state resources to reduce the impact of the budget on inequality between men and women and achieve gender equality in Ukraine, which necessitates further in-depth study of this issue.

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ГЕНДЕРНА СКЛАДОВА РИЗИКІВ БЮДЖЕТНОГО ПРОЦЕСУ В УКРАЇНІ

Вступ. Досліджено гендерні аспекти бюджетного процесу в Україні, зокрема і впровадження гендерного бюджетування, а також оцінювання ризиків, які виникають під час реалізації управлінських рішень на всіх стадіях бюджетного процесу органів державної влади України.

Методи. Застосовано комплекс основних загальнонаукових і спеціальних методів задля різнобічного вивчення предмету дослідження.

Результати. Наведено результати проведеного розгляду інституційно-правового середовища гендерних аспектів ризиків бюджетного процесу на державному рівні. Процес упровадження гендерно орієнтованого бюджетування розпорядниками бюджетних коштів усіх рівнів супроводжується низкою ризиків, які виникають на кожній стадії бюджетного процесу та потребують вчасного реагування на них шляхом прийняття відповідних управлінських рішень уповноваженими посадовими особами щодо мінімізації або уникнення ідентифікованих та оцінених ризиків. Для цього потрібно регулярно проводити аналіз та оцінювання впливу прийнятих бюджетних рішень щодо врахування гендерних аспектів і можливих наслідків таких рішень. Після виконання зазначеного аналізу наведено перелік ризиків на кожній стадії бюджетного процесу, можливі наслідки неврахування гендерних аспектів зазначених ризиків. Проаналізовано результативні показники діяльності Державного бюро розслідувань та Офісу Генерального прокурора, запропоновано проєкт алгоритму врахування гендерних аспектів в оцінюванні ризиків бюджетного процесу.

Висновки. На основі проведеного дослідження наведено приклади ризиків на всіх стадіях бюджетного процесу з урахуванням гендерних аспектів, надано їм характеристику та наголошено про необхідність продовження розроблення поглибленої методологічної підтримки для оцінювання ризиків бюджетного процесу на предмет врахування гендерних аспектів на всіх його стадіях при здійсненні діяльності державними органами України. Результати дослідження доводять, що впровадження гендерного підходу на всіх стадіях бюджетного процесу сприятиме ефективному розподілу державних фінансових ресурсів, створить необхідні передумови для спрямування бюджетних видатків на потреби конкретних цільових груп без залучення додаткових бюджетних асигнувань, завдяки чому буде забезпечено врахування потреб кожного члена суспільства на рівноправних засадах.

Ключові слова: бюджетний процес, бюджетне законодавство, гендерні аспекти, гендерне бюджетування, гендерно орієнтований підхід, ризики бюджетного процесу, стадії бюджетного процесу, управління ризиками бюджетного процесу.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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KEY TRENDS IN GOVERNING UKRAINE'S ENERGY SECTOR IN THE CONTEXT OF MILITARY AGGRESSION

Background. *The energy sector of Ukraine is a critical component of the national infrastructure. In Ukraine, this issue is especially relevant under the influence of military aggression, since its facilities in all sectors (from mining to electricity generation and oil refining) are being constantly destroyed. The restoration of the energy sector of Ukraine and its further development require new approaches to its management and the application of new technologies to increase the efficiency of resource use. The purpose of the study is to identify key trends and develop approaches to the intensive use of Ukraine's energy resources using the latest technologies. The task of the study is to determine the prospects for using cogeneration to rebuild the energy sector of Ukraine. The object of the study is approaches to the intensive use of energy resources. The subject of the study: the main tools for rebuilding the energy sector of Ukraine.*

Methods. *The methodological basis of the study is general scientific and special methods of scientific knowledge, in particular, theoretical and methodological analysis of modern literature on the development of the energy sector, and documents of world organizations in the energy sector. The method of analysis and synthesis was used to generalize and provide a unified approach to highlighting the advantages and disadvantages of the above-mentioned tools for rebuilding the energy sector. SWOT and PESTEL analyses were also used to determine the advantages and disadvantages of using cogeneration as a tool for rebuilding the energy sector of Ukraine.*

Results. *The study showed that significant destruction in the energy sector of Ukraine requires the application of new strategies for its development. Damage to electricity generation facilities requires their restoration on the principles of low-carbon technologies, and attacks on oil and gas fields led to the need to restore previously preserved sources of hydrocarbons. It was determined that the use of deposits that were closed due to unprofitability requires the transition to new, more modern technologies, which will allow for an increase in the resource base of hydrocarbons and, using cogeneration of energy, to solve the problem of energy independence and ecology.*

Conclusions. *The introduction of cogeneration in the current conditions and war will allow attracting additional investments to increase the extractable reserves of oil and gas, maintain hydrocarbon production at the current level to increase electricity production, achieve energy stability and autonomy, save fuel, reduce the country's energy dependence, solve environmental safety, etc.*

Keywords: *oil, gas, inactive deposits, liquidated wells, oil and gas industry, production, cogeneration, difficult-to-extract reserves.*

Background

Ukraine's energy sector is a critical component of the national infrastructure, as the sustainability of all social, economic, and defence institutions of the country depends on its functioning. The energy sector is the basis for the development of the national economy. In Ukraine, this issue is especially relevant because of the military aggression, as there is constant destruction of its facilities in all its segments (from mining to electricity generation and oil refining). The reconstruction of Ukraine's energy sector and its further development are based not only on the availability of adequate financing but also require new approaches to its management and the application of new technologies to increase the efficiency of resource use. Modern challenges caused by ongoing political and geopolitical tensions, as well as significant destruction of the energy infrastructure due to military actions, pose a daunting task for the Ukrainian government to restore destroyed facilities and to develop a strategy for the protection and recovery of all segments of the energy sector, taking into account the prospects of European integration.

The purpose of the study is to identify key trends and develop approaches to the intensive use of Ukraine's energy resources using the latest technologies. The objective of the study is to determine the prospects for using cogeneration to rebuild the energy sector of Ukraine.

Literature review. The object of the research is the approaches to the intensive use of energy resources. The subject of the research is the main instruments for the reconstruction of the energy sector of Ukraine.

In economic literature, the issue of forming a modern strategy for developing a sustainable renewable energy sector is actively considered. For example, Sulich and Sołoducho-Pelc (2022) conducted a thorough study of the main directions of transformation of the energy sector development strategies. They found that modern strategies not only prioritize technological solutions but are also based on the sustainable development of the sector and the economy as a whole. Markovska, Taseska and Pop-Jordanov (2009) made an attempt to determine the optimal strategy for its sustainable development based on a SWOT analysis of the energy sector of Macedonia. They recommended the use of natural gas, economically reasonable electricity prices, increased energy efficiency, and the use of renewable energy as the basis for further development of the sector in the country. Papież, Śmiech and Frodyma (2019) analysed the impact of the development of the renewable energy sector on the relationship between electricity consumption and economic growth in the EU countries in 1995-2015. The authors found that the development of the renewable energy sector has a positive impact on economic growth. Dzikuć et al. (2021) considered the issue of abandoning the excessive use of solid fuels. They emphasized that Poland is currently trying to catch up with other EU countries in its economic development, but to do this, it needs to switch to low-carbon technologies. They noticed that a component of such a process should be the transition to renewable energy sources. Strielkowski et al. (2024) examined the main directions of the energy sector transformation in European

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countries to reduce harmful emissions within the framework of the Paris Climate Agreement and identified six groups of countries depending on the strategy they use on the path to sustainable development of the sector. One of the main criteria for the analysis was the share of renewable energy in its total production. Lorek, and Lorek (2023) proposed a concept for modernizing the sustainable energy segment, taking into account the EU policy and the principles of sustainable electricity generation. They noted that some factors (energy and economic crises) do not contribute to an effective transition to renewable energy. Liu et al. (2022) highlighted that very often a trilemma arises when building a strategy for the development of the energy sector, that is, a conflict between three challenges: equitable access to energy, energy security, and environmental protection. The authors considered that achieving all three goals simultaneously is impossible, the environment suffers the most, and the countries with the largest greenhouse gas emissions are in no hurry to improve the situation. Juhola et al. (2024) examined the impact of renewable energy on climate change mitigation, as well as the impact of climate risks on energy companies operating in the renewable energy sector. They argued that companies typically ignore these risks because they consider them insignificant.

Another area of research that is popular in the economic literature is the use of cogeneration to build a sustainable energy sector. Particularly, Çakır, Comaklı and Yüksel (2012) considered the cogeneration system as one of the ways to save energy, increase energy efficiency, and reduce carbon emissions. Oh et al. (2007) examined the commercial use of cogeneration plants jointly producing electricity and heat to determine their optimal size from an economic perspective. According to the authors, the payback period of the investment and the rate of return are crucial. Also, a popular area of research is the impact of cogeneration on energy sector transformation strategies to increase its sustainability (He et al. 2021; Ma et al. 2021; Salehi et al. 2021).

The work of many scientists, both domestic and foreign, is dedicated to the study of the problems in the energy sector and the innovative and investment development of the energy sources. Thus, the issues of energy investment by regions of the world were revealed in the work of Stepanova. The author proved the importance of investing in the energy sector for the entire developed world and identified the priorities of this process, the ways to solve Ukraine's energy dependence, taking into account existing world best practices. In the research by Hernego and Lyakhova (2021) dedicated to the investments in alternative energy in Ukraine, it was proven that increasing the potential of alternative energy in Ukraine is associated with the possibility of attracting financial resources from various sources. Based on a study of practical aspects of financing renewable energy sources, the features of financing the potential for the development of alternative energy in Ukraine are revealed, and the factors that determine it are identified. Babina identified and systematized the features of innovation and investment activities in the development of alternative energy sources and substantiated ways to implement world best practices in innovation and investment activities for the development of alternative energy sources in Ukraine (Babina, 2020). The author has improved the economic and mathematical modelling of the development of alternative energy sources, which allows for creating multivariate forecasts for the development of alternative energy sources by regions of Ukraine, as well as to develop a framework for the development of alternative energy

sources. Samoilenko (2018) considered the innovation and investment frameworks for the development of the energy market of Ukraine, and established the need to implement regulatory benchmarking as a measure that allows for determining the reference level of efficiency of an energy company in several key aspects, such as operational and investment activities, and in such factors as reliability, costs, and losses. In particular, Sobolev and Zatonatska (2024) focused on the main directions of further development of the energy sector of Ukraine within the framework of the implementation of the state strategy. The authors proposed their own definition of the energy sector, which was based on such components as the main segments of energy demand and the energy supply segment. The authors concluded that the successful implementation of Ukraine's national energy strategy requires further improvement of the regulatory environment, expansion of economic support instruments, and intensification of international cooperation. Another area of research that is popular in the scientific literature is the use of cogeneration to build a sustainable energy sector. Thus, Khodakivskyi and Karpenko attempted to determine the effectiveness of the implementation of cogeneration in the conditions of modernization and redundancy of the heat supply system (Khodakivskyi and Karpenko, 2025). The analysis of the efficiency of centralized and decentralized heating systems, including Power-to-Heat technologies, conducted by the authors, showed that distributed generation systems, electrification of heat supply, and the introduction of renewable energy sources can significantly reduce greenhouse gas emissions and increase the reliability of energy infrastructure. Andreev et al. (2015) conducted a thorough study dedicated to the analysis of low-power power generating units used in the conversion of existing boiler houses into mini-CHP plants. Their work presented comparative features of gas piston engines and gas turbine plants for small power generating facilities, and assessed the possibilities of implementing cogeneration principles. The researchers carried out feasibility studies on the implementation of a superstructure based on GPA, focusing on the impact of gas prices on the project's payback period, which is extremely important in today's conditions of energy instability. Stepanov and Resident (2023) determined the impact of the ratio of gas and electricity prices on the economic efficiency of combined heat and power generation using natural gas. They showed that using a cogeneration plant to cover one's own electrical needs is economically feasible if the ratio of prices for electricity and natural gas is more than 2.4. The authors confirmed that cogeneration is economically feasible, but has significant investment payback periods. However, despite significant scientific achievements in this area, not all issues related to the formation of Ukraine's energy sector during the military aggression have yet been resolved, which makes this area of research relevant.

Methods

The methodological basis is a combination of general scientific and special methods. A theoretical and methodological analysis of modern scientific literature on the problems of energy sector transformation, as well as official documents and analytics of international organizations in the field of energy, was applied. To generalize approaches and identify discussion fields, methods of analysis and synthesis, induction and deduction, comparative and systemic approaches were used. The empirical part is based on statistical methods for processing time series: construction of indices, calculation of chain and basic growth/decline rates, moving averages, as well as the ratios

"investment → production" for oil and gas. To preliminarily identify the relationship between the dynamics of capital investment and actual production volumes, the correlation approach and elastic estimates (in percentage changes year-on-year) were applied. Institutional and political-economic analyses were used to interpret the obtained quantitative results in the context of military risks and regulatory constraints. The assessment of strategic directions for reconstruction was carried out through two complementary frameworks, including SWOT analysis and PESTEL analysis of the implementation of cogeneration, taking into account the conditions of wartime and post-war recovery. Additionally, elements of the scenario approach and case analysis were applied. The source database includes official statistics, specialized government publications, as well as analytics from international organisations and industry research reviews.

Limitations. Due to the martial law and increased confidentiality requirements, official statistics after 2022 have significant limitations. The calculations used an agreed assumption regarding the proportional distribution of investments between the gas and oil segments. At the same time, the lack of quarterly data and possible structural gaps in reporting do not allow for drawing unambiguous cause-and-effect conclusions. The obtained results of correlation and elastic estimates are considered indicative. To increase the reliability of the conclusions, methodological triangulation was used, involving a combination of quantitative and qualitative approaches.

Results

In the modern world, the concept of the green economy is actively developing, which involves the transformation and further development of the energy sector according to a new scenario focused on renewable energy, reducing greenhouse gas emissions, waste, and environmental protection. Ratification of the Paris Climate Agreement of December 12,

2015 and implementation of relevant measures by its signatories would provide several significant positive effects by 2040: increasing electricity production from renewable energy sources (RES) to 37% in the overall electricity production structure; using RES for new capacities at 60% and increasing their competitiveness; increasing the number of electric vehicles to 150 million units, etc. If these projections come true, CO₂ emissions from the global energy sector will grow by an average of 0.5% annually, compared to an average of 2.4% since 2000. This indicates the need for a more active transition to carbon-neutral development, in particular, through the transformation of the energy sector of the economy. The fundamental principle of decarbonising the energy sector is the transition from traditional energy production and consumption systems based on fossil fuels, such as oil, natural gas, and coal, to the expansion of renewable energy sources, the implementation of non-traditional sources, as well as the improvement of energy transmission and storage systems.

Renewable energy sources play a key role in shaping a new energy paradigm that not only meets the requirements of environmental sustainability but also stimulates significant economic shifts. In Ukraine, as it combats difficult challenges due to military aggression, the implementation of strategies for transitioning to renewable energy sources can promote economic growth, reduce dependence on imported energy resources, increase energy security, and create new jobs.

According to forecasts by the International Renewable Energy Agency, the global transition to renewable energy sources by 2030 could add more than \$4 trillion to the world economy and create more than 20 million new jobs. At the same time, to achieve the baseline scenario by 2030, global investments in renewable energy sources must increase significantly, meaning at least threefold. These trends are also reflected in the development of the global renewable energy market (Fig. 1).

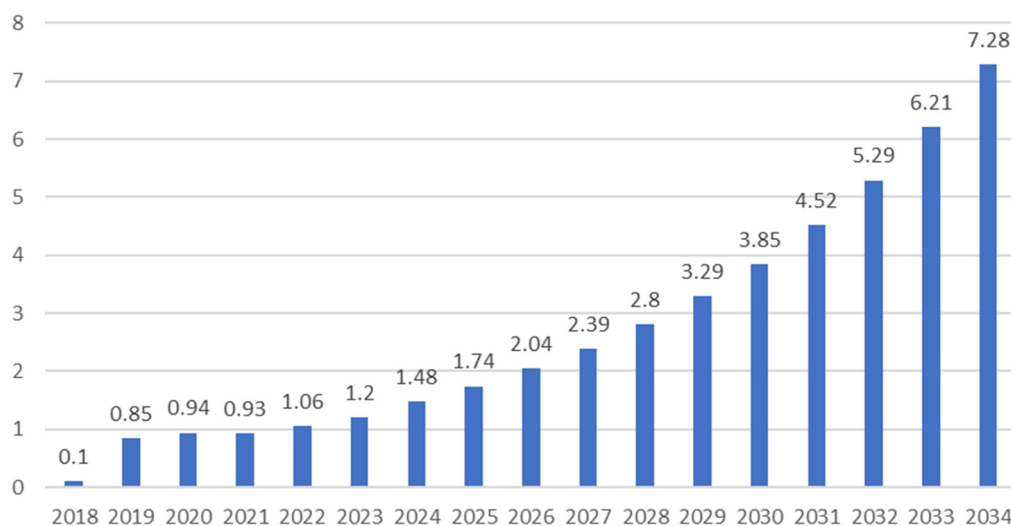


Fig. 1. Global renewable energy market (trillions of U.S. dollars)

Source: compiled by the author based on data from Precedence Research 2025 and Grand View Research 2024. Forecast starting from 2025.

If in 2018 the volume of this market was only 0.1 trillion USD, then according to forecasts for 2025, this figure will reach 1.74 trillion USD. The global renewable energy market is expected to reach 7.28 trillion USD by 2034, with a compound annual growth rate of 17.23% between 2025 and 2034. This shows evidence of significant demand for clean energy in various sectors of the global economy.

Ukraine is actively seeking integration into the European Union, and the practices of the EU member states in the field of renewable energy are an important guide for us. It should be noted that the transition to energy transformation is an important step to ensure sustainable development and stability of Ukraine's energy system in the future. However, the implementation of this policy is impossible without overcoming the consequences of military destruction

caused by Russia's armed aggression. As a result of this destruction, the energy infrastructure (Fig. 2) and the country's economic base suffered significantly, which complicates the process of transitioning to renewable energy sources and increasing energy efficiency. Therefore,

the recovery of damaged energy infrastructure facilities is an important stage in the context of the overall energy transformation, which should ensure not only the sustainability of the energy system but also create conditions for sustainable socio-economic development.

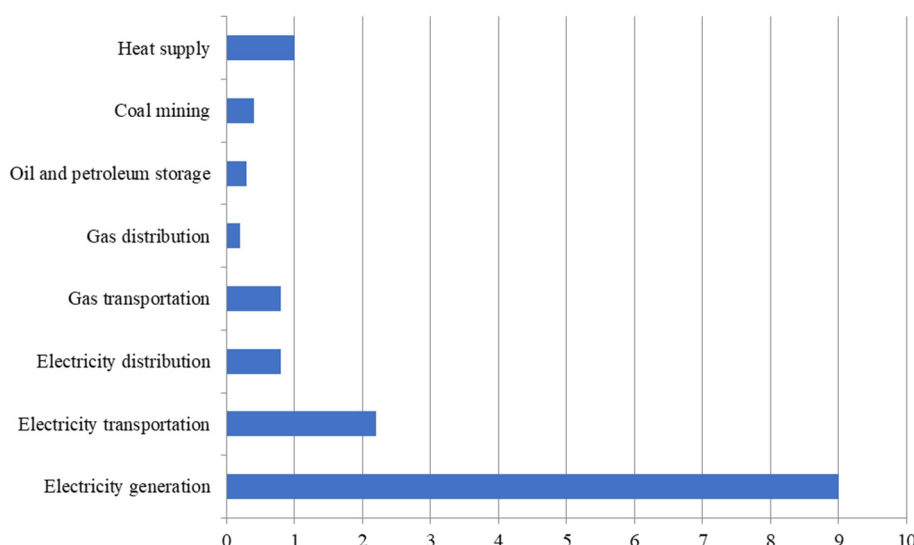


Fig. 2. Direct losses of Ukraine's energy sector as a result of the armed conflict (billions of U.S. dollars)

Source: compiled by the author based on data from Report on Direct Damage to Infrastructure from Destruction as a Result of Russia's Military Aggression against Ukraine (as of November 2024).

Total direct damage from destruction due to military aggression as of November 2024 is estimated at 14.6 billion USD. This reflects the scale of the destruction, particularly in the electricity generation and transmission sector, which is most vulnerable to shelling and attacks by the aggressor. Damages caused to energy facilities amount to over 12 billion USD, with a significant portion of them occurring at large generation facilities. Massive missile strikes on thermal and hydroelectric power plants resulted in damage or destruction of a significant number of turbines, generators, and auxiliary equipment. One example is the destruction of the Kakhovka hydroelectric power plant in June 2023, which caused losses in excess of \$0.6 billion USD. Critical damage was sustained by thermal generation facilities: as a result of massive shelling, several key thermal power plants and CHP plants were destroyed or put out of action, such as Burshtynska TPP, Ladyzhynska TPP, and Trypil'ska TPP.

Gas transportation and distribution suffered losses estimated at USD 0.8 billion and USD 0.2 billion, respectively. Damage to gas pipelines and gas distribution stations has caused a chronic gas shortage, which is particularly acute at the level of industrial enterprises and the population, particularly in the winter. Given the critical importance of this infrastructure for the country's energy security, its restoration is an important task to ensure a stable energy supply. The storage of oil and petroleum products suffered losses of USD 0.3 billion, and the coal mining industry lost USD 0.4 billion. Part of the coal mining industry, in particular mines and quarries for coal extraction, is located in territories where active hostilities are taking place or which have already been captured by the enemy. This significantly limited access to the necessary resources for thermal power plants that use coal as their main fuel. As a result, Ukraine has become significantly dependent on imported energy sources, which increases the vulnerability of energy infrastructure and creates additional risks to the

country's energy security. Additionally, electricity generation facilities from renewable sources also suffered serious losses. A significant portion of solar and wind generation capacity was located in temporarily occupied territories, resulting in the loss of 13% of solar generation capacity and almost 80% of wind generation capacity. Constant shelling of energy facilities has led to the destruction or serious damage of more than 20% of renewable capacity. Current direct losses for the renewable energy segment are estimated at \$0.3 billion USD (as of November 2024).

Despite the serious destruction caused by the war and the need to restore a significant part of the energy infrastructure, it is important to note that the existing infrastructure has long required modernization. It is outdated and worn out, which complicates the efficient use of resources and increases risks to energy security. Therefore, along with the restoration of damaged facilities, it is necessary to direct efforts to the development and implementation of innovative solutions and investment changes in the management of the energy sector. This will not only ensure the stability of the energy sector but also contribute to its long-term modernization and efficiency improvement.

Ukraine's oil and gas industry consists of three main sectors: hydrocarbon exploration and production, hydrocarbon transportation and storage, as well as processing and distribution. Each of these sectors plays an important role in the country's energy independence, but the hydrocarbon exploration and production sector occupies a key position. It is the structural element, as it ensures the growth of resources, stability, and development of the entire oil and gas industry, and therefore the energy security of the state. Analysis of data on oil production in Ukraine in recent years indicates a negative trend of decreasing production volumes, which became even more pronounced after the start of Russia's armed aggression.

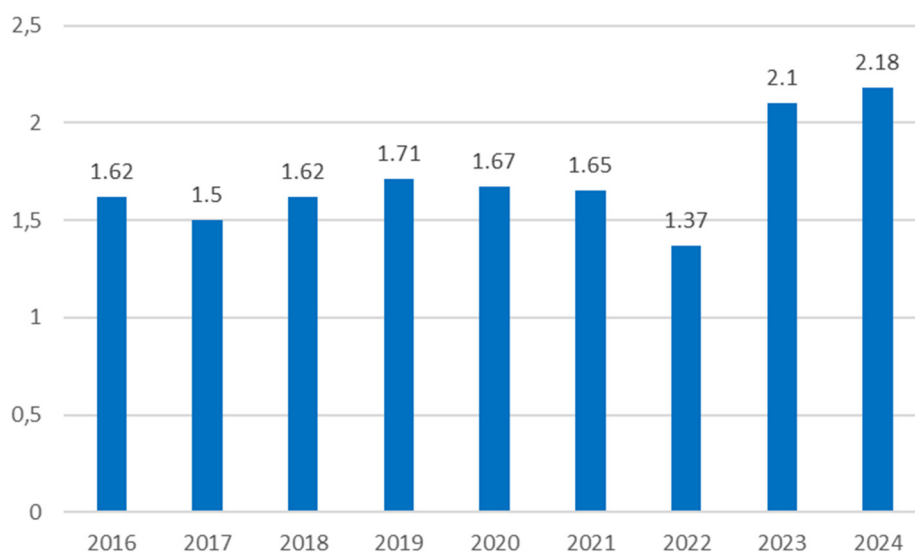


Fig. 3. Dynamics of oil production (million tons)

Source: compiled by the author based on data from the State Statistics Service 2024 of Ukraine and open sources.

According to the data in Fig. 3, in 2016, oil production was at the level of 1.62 million tons; however, in 2022, it decreased to 1.37 million tons, which indicates a significant reduction in extractable resources. The negative impact of Russian aggression, particularly in the territories where oil and gas fields are located, has complicated the process of

hydrocarbon extraction. Although oil production increased to 2.1 million tons in 2023 and 2.18 million tons in 2024, it cannot fully compensate for the losses caused by both the long-term trend of declining production and the destruction caused by the war.

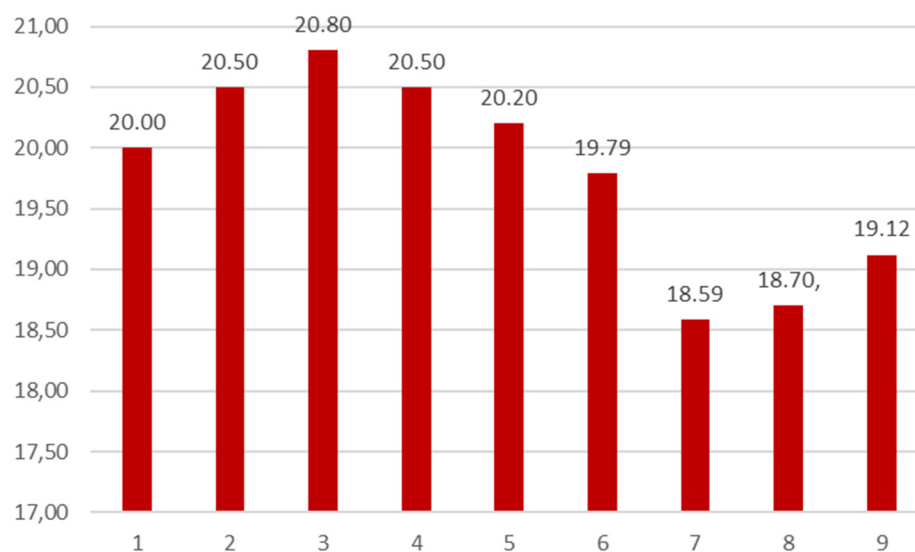


Fig. 4. Dynamics of gas production (billion m³)

Source: compiled by the author based on data from the State Statistics Service of Ukraine 2024 and open sources. Since 2022, gas and condensate production have been reported as a single indicator.

Analysis of data on gas production in Ukraine in recent years also indicates negative trends. According to the dynamics shown in Fig.4, in 2016 the volume of production was 20 billion m³, but by 2022 it decreased to 18.59 billion m³. The steady decline is due to a number of factors, including infrastructure problems, equipment wear and tear, and, of course, military operations. 2023 was marked by a slight increase in production to 18.7 billion m³, which continued into 2024 (19.12 billion m³). However, this growth cannot compensate for the shortage of gas in gas storage facilities. As of early spring 2025, about 5 billion m³ of gas remained in the underground storage facilities of the gas transportation system of Ukraine, and in February 2025, it

was necessary to urgently purchase 0.5 billion m³, while 0.8 billion m³ was required. It should be noted that for the stable passage of the 2025–2026 winter season, Ukrainian underground storage facilities need to accumulate at least 12.8 billion m³ of gas, including 4.6 billion m³ of so-called buffer gas, necessary to maintain pressure in storage facilities. Despite all the efforts of the oil and gas complex, this is impossible in conditions of constant shelling. Only import remains.

It should be noted that the systemic stagnation observed in the oil and gas industry negatively affects the economy of Ukraine, since the industry has a significant share in the country's GDP. At the same time, a decrease in production

leads to a decrease in energy independence, as the country becomes more dependent on energy imports, which, in turn, increases the vulnerability of the national economy to external economic and political factors. In such conditions, the role of the state in creating and implementing innovative changes in the oil and gas industry becomes particularly important. It should become the main driver of the industry's development, creating conditions for the inflow of investments and stabilization of hydrocarbon production. Innovations in exploration and production, the use of the latest technologies and drilling methods, as well as

improving infrastructure for transporting and storing hydrocarbons, can become key factors in ensuring the stable development of the industry and increasing the country's energy independence in the face of global changes in energy markets.

Overall, despite some recovery in 2023–2024, the general trend towards a decrease in hydrocarbon production threatens the country's energy security, which requires comprehensive measures to attract significant investments to the industry (Fig. 5).

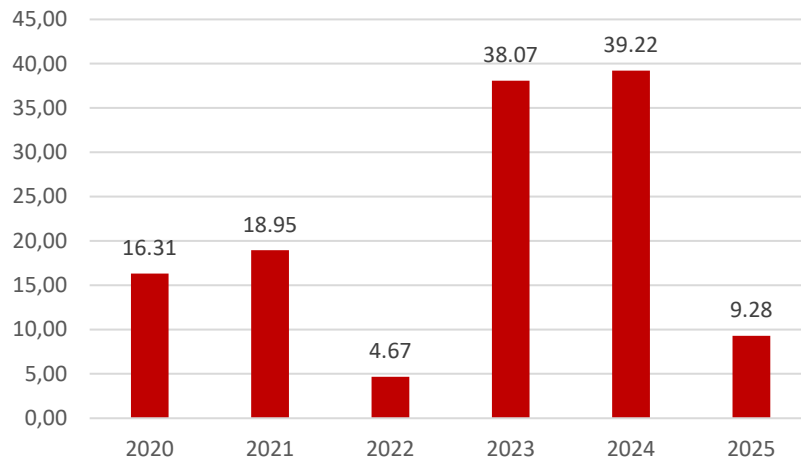


Fig. 5. Capital investments in oil, gas, and condensate production, billion UAH

Source: compiled by the author based on data from the State Statistics Service of Ukraine 2025.

Our analysis of capital investments in oil, gas, and condensate production in Ukraine shows significant fluctuations, indicating the serious challenges the industry has faced amid the armed conflict and economic difficulties. In 2020, capital investments in the sector amounted to UAH 16.306 billion, representing a relatively stable level. In 2021, investments increased to UAH 18.951 billion.

(+16.2%), indicating some improvement in the conditions for the development of the oil and gas industry, likely due to a more stable economic situation and partial recovery from the COVID-19 pandemic. However, in 2022, investments decreased sharply to UAH 4.672 billion (–75.3%). This significant reduction is explained by the beginning of Russia's armed aggression against Ukraine, which caused large-scale destruction of infrastructure, particularly in the oil and gas sector. Not only did physical facilities suffer from shelling and combat operations, but investors also became more cautious due to the sharp increase in risks, which negatively affected the volume of capital investment. However, in 2023, there has already been a significant increase in capital investments to UAH

38.07 billion (+714.6% compared to 2022), which indicates the state's efforts to restore the industry and attract new financial resources to stabilize oil and gas production. This growth resulted from government support and investment incentives, as well as efforts to adapt to new conditions and the urgent need to restore critical energy infrastructure. In 2024, capital investments continued to grow, reaching UAH 39.221 billion (+3.0 %). This trend is a positive signal for the industry and demonstrates its capacity to develop despite ongoing challenges. However, data for the first quarter of 2025 – showing capital investments of UAH 9.282 billion compared to the same period in 2024 – indicate a potential slowdown in investment growth, creating risks for the stability of the industry's development in the short and medium term.

Our analysis of the dynamics of capital investments in oil and gas production in Ukraine relative to the actual indicators of hydrocarbon production allows us to trace a clear relationship between the volume of invested resources and the performance of the industry (Table 1).

Table 1

Dynamics of changes in investments and oil and gas production in Ukraine

Year	Total investments, billion UAH	%	Investments in gas, billion UAH	Investments in oil, billion UAH	Gas production, billion m ³	%	Oil production, million tons	%
2020	16.306	–	15.16	1.145	20.2	–	1.675	–
2021	18.951	+16.2	17.63	1.32	19.79	–2.0	1.65	–1.5
2022	4.672	–75.3	4.35	0.33	18.59	–6.1	1.37	–15.7
2023	38.07	+714.6	35.4	2.6	18.7	+0.6	2.1	+53.6
2024	39.221	+3.0	36.5	2.7	19.12	+2.3	2.18	+3.8

Source: compiled by the author based on data from the State Statistics Service of Ukraine.

In 2020, the total volume of capital investments in oil, gas, and condensate production amounted to UAH 16.306 billion. At the same time, there was a clear imbalance in the distribution of funds: oil received UAH 1.145 billion (7 % of the total amount); gas accounted for UAH 15.16 billion (93 %). This confirms the state's strategic focus on supporting the gas production sector, whereas the oil sector remained relatively secondary in terms of investment. The lack of official detailing by industry sector after 2020 is explained by the confidentiality requirements of the Law of Ukraine "On Official Statistics" dated August 16, 2022, No. 2524-IX. However, if we conditionally apply the ratio of 93% (gas) to 7% (oil) for the following years, we can trace the following patterns:

- In 2021, investments increased to UAH 18.951 billion. This means that the gas production sector could have accounted for about UAH 17.6 billion, while the oil sector for only UAH 1.3 billion. This imbalance logically explains why oil production grew only symbolically (+0.2%), while gas showed a more noticeable increase (+2.5%).

- In 2022, the total volume of investments fell sharply to UAH 4.672 billion (-75.3 %). Applying the previous ratio, gas would account for about UAH 4.35 billion, and oil would account for less than UAH 0.33 billion. This decline was reflected in production: oil fell by 15.7%, and gas by 9.5%. Thus, the investment deficit immediately affected production volumes, and in the oil and gas balance, it was the oil segment that suffered the greatest losses.

- In 2023, investments recovered to UAH 38.07 billion (+714.6 %). Under the conditional distribution, gas got UAH 35.4 billion; oil got UAH 2.6 billion. In the same year, oil production increased by 53.6%, and gas production by only 0.6%. This difference is explained by the fact that even a small additional inflow of funds into the oil sector (from UAH 0.3 to 2.6 billion) had an instant effect, while gas production, due to high inertia and a long investment cycle, reacts much more slowly.

- In 2024, investments increased by another 2.9%, reaching UAH 39.221 billion. Following the same proportion, gas received about 36.5 billion UAH and oil 2.7 billion UAH. As a result, oil production increased by 3.8% and gas by 2.3%. This demonstrates that a gradual increase in investment in wartime conditions still allows for the stabilization of production, although the effect is different for different sectors of the industry.

In general, the growth of capital investment in oil and gas production shows a positive correlation with production volumes, but this effect depends on the scale of investment and the existing challenges. We have come to the conclusion that in Ukraine, we can observe: the dominance of the gas sector, as about 90% of all investments were directed specifically to gas production, while oil remained underfunded. This led to a long-term decline in oil production, despite the overall growth in investments in 2021. The analysis reveals several key patterns: **high sensitivity of oil production** – even a small increase in investments in the oil segment (for example, from UAH 0.33 billion in 2022 to UAH 2.6 billion in 2023) produced a rapid effect, resulting in a sharp increase in production (+53.6%); **inertia of gas production** – the gas industry reacts slowly even to substantial increases in investments, which can be explained by the long cycles required for drilling new wells, developing infrastructure, and commissioning new capacities; **war as a key factor** – the sharp decline in investments in 2022 and the subsequent reduction in production confirm that military actions and the destruction of infrastructure remain the decisive factors behind the stagnation of the industry; **strategic need** – to restore

Ukraine's energy independence, it is essential to balance investments between the oil and gas sectors, with a special emphasis on modernization and innovation. This approach would help reduce the investment lag in gas production and enhance the overall efficiency of investments in the oil and gas sector. For stable development and sustainable production growth, it is necessary to attract investment, promote innovation within the industry, and continue the restoration of critical infrastructure.

At the beginning of Ukraine's independence, significant volumes of associated petroleum gas (APG) were lost through flaring due to technological imperfections in collection and preparation systems, as well as the remoteness of the fields from the main gas infrastructure. In the absence of economic incentives and against the backdrop of relatively cheap electricity from nuclear power plants, cogeneration projects were considered secondary. From an economic point of view, this meant lost profits: instead of converting APG into commercial electrical and thermal energy, there was a direct destruction of the resource without a multiplier effect on GDP and local budgets. Nowadays, taking into account military risks, capacity shortages, and high volatility of fuel markets, cogeneration is becoming a priority vector of investment. Its key advantage is high fuel efficiency due to the simultaneous production of electricity and useful heat, which reduces specific fuel consumption and the cost of energy for industry and district heating, and power utilities. Additional economic effect is formed by: reducing system balancing costs through distributed sources close to consumption; reducing network losses and capital-intensive investments in its transmission; "monetizing" previously lost APG. From an energy security perspective, decentralized cogeneration increases resilience to attacks on mainline infrastructure and reduces dependence on imports.

Cogeneration technology is not new to Ukraine, but its large-scale implementation has remained limited for a long time. In practice, the use of cogeneration units was concentrated mainly in large cities based on thermal power plants (TPPs), where they served as manoeuvring capacities with the ability to quickly respond to fluctuations in demand. Such stations operated mainly on traditional fuels such as coal, natural gas, or fuel oil. According to data until 2021, the share of cogeneration in the structure of electricity production in Ukraine was about 27% of the total generation volume. However, this dynamics did not have stable growth in 2016-2021, which indicates the lack of systemic investment support and proper state policy for the development of the industry. After the start of Russia's large-scale aggression, the situation became even more complicated: the availability of statistical data has declined, and energy infrastructure has suffered significant damage. At the same time, official data from the National Commission for State Regulation of Energy and Utilities (NCRECU) for 2023 indicate a significant drop: electricity production from cogeneration TPPs decreased by 4.1% compared to 2022 and by 37.3% compared to 2021 (TEK, 2021). This decline reflects both wartime destruction and chronic underfunding of the industry's modernization. In such a situation, cogeneration takes on particular importance from an economic point of view. Firstly, it is a tool for increasing energy efficiency: simultaneous production of heat and electricity allows achieving a fuel utilization ratio of 80-90%, which significantly exceeds the performance of traditional generation. Secondly, the development of cogeneration technologies can reduce dependence on energy imports, since cogeneration plants can be built closer to consumers,

using local resources. Thirdly, they form an investment-attractive segment in the war and post-war period: investments in cogeneration are less capital-intensive than the construction of large thermal power plants or hydroelectric power plants, but provide a faster economic effect due to flexibility and decentralization.

However, the situation with cogeneration does not look hopeless. Thus, in 2024 alone, 68 cogeneration plants with a total electrical capacity of 77 MW were put into operation; in the first five months of 2025, 29 plants with an electrical capacity of 377 MW and a thermal capacity of 1,625 MW were qualified. Experience shows that some installations do not meet the criteria for high efficiency. The main reasons are too low electricity production, as well as the use of outdated equipment with low efficiency, sometimes over 50 years old. To increase efficiency and obtain the status of highly efficient cogeneration, the State Agency for Energy Efficiency and Energy Saving of Ukraine recommends that owners of such installations conduct energy audits, implement accurate energy accounting systems, consider switching to alternative fuels, prepare feasibility studies for modernization, and seek financing through available financial programs (Ukraine and the EU, 2025). Thus, the further development of cogeneration capacities in Ukraine

requires technical modernization, a targeted innovation and investment strategy, and international investment support.

State innovation and investment policy in the energy sector is gaining particular importance in the current conditions of military challenges and transformational dynamics of the Ukrainian economy. It forms the basis for implementing the economic growth strategy, ensuring the integration of scientific and technological achievements into production processes and creating the prerequisites for increasing the competitiveness of the national economy. An energy sector capable of rapid adaptation and implementation of innovative technologies, including in the cogeneration segment, is becoming a key factor in sustainable development. Investments in the modernization and development of such technologies increase energy efficiency and create a multiplier effect for related industries, stimulating socio-economic changes. So, to determine the strategic priorities for the innovative development of Ukraine's oil and gas industry in the face of military threats and global energy transformation, it is advisable to use the SWOT analysis tool kit. This allows for a comprehensive assessment of the industry's internal strengths and weaknesses, as well as external opportunities and threats that will determine the prospects for its further evolution (Table 2).

Table 2

SWOT analysis of the implementation of innovations in the oil and gas industry of Ukraine

Strengths	Weaknesses
Experience. Ukraine has many years of experience in the production, transportation, and processing of oil and gas, which provides a basis for implementing innovations. International support. Active cooperation with international partners and organizations provides the opportunity to obtain modern technologies and investments. Resources. The presence of our own oil and gas reserves, including unconventional ones, which can be used more efficiently with the help of the latest technologies. Developed infrastructure. Oil and gas infrastructure, although damaged, is still ready for modernization in a relatively short period of time. Investments. In the context of war with Russia, the governments of Ukraine and the United States signed a mineral agreement that will allow attracting foreign capital to develop the industry.	Import dependence. High dependence on energy imports, especially in times of war, complicates the stability of supply. Outdated infrastructure. A significant part of the infrastructure needs modernization, which requires significant financial investments. Economic constraints. Limited financial resources due to war and economic crisis, which limit opportunities for innovation. Security risks. Military actions and the constant threat of attacks on energy infrastructure. Occupation. Some of the oil and gas fields are located in occupied territories or directly in the combat zone.
Opportunities	Threats
Investments in fields written off from the State Balance Sheet. Re-liquidation of inactive fields and wells for re-production of oil and gas. Cogeneration. The construction of cogeneration plants will combine the oil and gas and energy industries and reduce dependence on imported energy resources. Investment in renewable energy sources. The development of renewable energy sources within the oil and gas industries will reduce dependence on traditional energy resources in their extraction and processing. International assistance and grants. Obtaining international assistance and grants for the restoration and modernization of infrastructure. Development of new technologies. Introduction of modern technologies for the extraction and processing of energy resources, which will increase efficiency and safety.	A prolonged war. Continued military operations, constant destruction of infrastructure will significantly complicate the implementation of innovations and the development of the industry. Cybersecurity threat. Increased vulnerability to cyberattacks, which can lead to infrastructure disruptions. Market volatility. The instability of global energy markets, fluctuations in oil and gas prices can affect the economic stability of the industry.

The conducted SWOT analysis demonstrates a complex and at the same time multi-vector picture of the development of the oil and gas industry of Ukraine. Despite its existing strengths, such as its own resources, many years of experience, and international support, the industry remains vulnerable due to outdated infrastructure, limited financial resources, and military risks. At the same time, opportunities associated with the re-licensing of inactive fields, the development of cogeneration, and the integration of renewable energy sources open up prospects for modernization and reduced dependence on imports. Threats posed by war, cyberattacks, and instability in energy

markets underscore the need to strengthen public policy and create flexible innovation and investment mechanisms. Therefore, the strategic course should be aimed at maximizing the use of existing opportunities and neutralizing threats, which will create conditions for long-term energy security and economic sustainability of the state.

In modern conditions, which determine the priority areas for the development of the state's energy independence, it is necessary to focus efforts on the level of diversification of its sources and on the existing capabilities of our land. One of the sources of innovative development of the oil and gas industry is its closer connection with the energy sector,

which is currently in an extremely difficult situation. One of these areas that allows for the most effective use of one's own energy potential is cogeneration plants (cogeneration), which is a process that combines the production of electrical and thermal energy.

Innovative approaches to implementing cogeneration systems include:

- decentralization, changes in social and economic reforms in the state;
- development of technological and digital technologies;
- saving certain resources due to the implementation of modern technologies;
- use of low-pressure gas from certain fields and wells;
- use of oil refining products;
- use of renewable energy sources that have the ability to be constantly renewed.

Investment approaches for implementing cogeneration systems include:

- state support programs that provide conditions for energy transformation;

- organization of public-private partnerships that provide for their joint financing;

- participation in international grant programs that provide funds for the implementation of such initiatives;

- community support programs that provide for the modernization of individual complexes.

In order to form the conceptual foundations for the implementation of innovative cogeneration technologies based on depleted and liquidated fields (wells) of Ukraine in the context of military challenges, it is advisable to use the PESTEL analysis methodology. This approach allows for a systematic assessment of key environmental factors (political, economic, social, technological, environmental, and legal) that determine the possibilities and limitations of implementing the relevant process. The results of the analysis are integrated into Table 3, which reflects the impact of the external factors on the prospects for the implementation of cogeneration projects in the oil and gas industry of Ukraine in wartime conditions.

Table 3

PESTEL analysis of the implementation of cogeneration in depleted and liquidated fields (wells) of Ukraine in wartime conditions

Political Factors	Continuous destruction of the infrastructure of the oil and gas, and energy industries which makes stable operation and the possibility of implementing innovations impossible. Occupation of part of the oil and gas fields, coal and peat deposits, which are the main source of electricity production. Support of the authorities for the purpose of internal development and transition to European energy markets. The need to reform legislation to integrate into international law, to implement the mineral agreement concluded with the United States.
Economic Factors	Limited financial resources and low investment attractiveness due to the war. War and economic sanctions affect the stability of markets and the cost of energy resources, which affects the implementation of innovative projects. High dependence on gas imports and price fluctuations in European energy hubs increases vulnerability to external economic impacts.
Social Factors	The population's need for a stable supply of electricity. The need for highly qualified personnel to implement innovations and new technologies. High public support for the development of Ukraine's energy independence.
Technological Factors	Implementation of modern technologies for oil and gas production. Modernization of oil and gas infrastructure, including the re-liquidation of inactive fields and wells for the re-production of oil and gas.
Environmental Factors	Significant public support for the elimination of environmental pollution related to oil spills and gas emissions into the environment. The need to adapt to climate change and reduce greenhouse gas emissions.
Legal Factors	Reforming and implementing changes to the legislation of Ukraine regarding hydrocarbon production and obtaining special permits for subsoil use. Reforming legislation to integrate and harmonize with European legislation, which will promote transparency and attract investment. Ensuring legal protection of investments and compliance with international agreements, including mineral agreements with the United States.

As the PESTEL analysis shows, the key barriers to the implementation of cogeneration technologies are political instability, infrastructure destruction, and limited financial resources. At the same time, the opportunities are dominated by high public support for energy independence, the potential for using depleted wells, and the need to adapt to European standards. This creates the prerequisites for attracting both domestic and foreign investments, especially in the context of post-war reconstruction. Thus, cogeneration based on depleted deposits can become one of the strategic directions for modernizing the Ukrainian energy sector and strengthening its economic sustainability.

The key challenge remains overcoming the systemic asymmetry between the need to increase the resource base and safely increase production, and existing institutional and legal restrictions. Resolving this "inequality" requires an

urgent government initiative from relevant bodies with a package of solutions that simultaneously:

- harmonize Ukrainian legislation with European legislation (permitting procedures, environmental standards, guarantees of energy origin, etc.);

- launch financial instruments to accelerate investments (long-term loans from IFOs, partial CAPEX compensation, accelerated depreciation, "green" and transitional PPAs for electricity and heat contracts for cogeneration, etc.);

- provide regulatory predictability for private investors (stable rules for access to resources, transparent auctions, standardized connection agreements, etc.).

After the active phase of the war ends, the priority will be the re-privatization/recapitalization of "dormant" assets and the targeted scaling of distributed high-efficiency cogeneration based on APG and low-pressure gas as the fastest way to increase energy efficiency, reduce import

dependence, and stabilize local energy balances. At the same time, seismic exploration and reassessment of resources in the continental part should be launched, including infrastructure modernization of gas collection and preparation. According to estimates by a number of reputable experts, Ukraine's potential allows it to increase natural gas production up to ≈ 55 billion m^3/year in the medium term, provided that security is stabilized, the market is liberalized, and investments in exploration and production are scaled up. To implement this trajectory, an Energy Recovery Investment Fund with a clear mandate is needed: co-financing exploration, modernization of gas collection/processing infrastructure, and development of cogeneration projects (including heat contracts for communities and industry). Thus, an economically viable combination of (1) legal harmonization, (2) long-term investments, and (3) technological modernization, relying on highly efficient cogeneration and the prospect of offshore projects, is capable of ensuring a sustainable recovery of the energy sector, increasing production, and strengthening Ukraine's energy security.

Discussion and conclusions

The economic literature examines in detail the issue of energy sector transformation strategies used in the modern world. The main goal of such transformations is to achieve sustainable development of the sector, transition to low-carbon technologies, and promote environmental protection. One possible direction is the use of cogeneration using various technologies. Resolving these issues in the current conditions and war will allow attracting additional investments to increase recoverable oil and gas reserves, maintain hydrocarbon production at the current level to increase electricity production through cogeneration, achieve energy sustainability and autonomy, save fuel, reduce the country's energy dependence, address environmental safety, etc.

In general, the processes of forming strategies for managing the transition to a sustainable energy environment must take into account important socio-economic and political issues:

(1) Energy and financing. Appropriate strategies for transforming the energy sector include transparent long-term business planning, approaches to ensuring flexibility and balancing the system, as well as issues of increasing investment. Transparent step-by-step planning will ensure stability and efficient management with safe conditions for stakeholders in a liberalized and balanced energy market. Another important issue is the policy of attracting large amounts of investment needed in the energy sector. It is extremely important to guarantee security and transparency for investors and organizations financing renewable energy projects. This, in turn, can reduce the cost of renewable energy sources and the overall cost of the system.

(2) Stakeholders and government regulation. When planning the phase-out of fossil fuels and the transition to renewable energy sources, it is necessary to consider the need to involve key government stakeholders and relevant decision-making mechanisms. Involving a wide range of experts in decision-making on the use of appropriate policy instruments will ensure the harmonization of socio-economic processes at all levels of the economy. In particular, state institutions form and approve regulatory legal acts and development strategies for countries and industries in the field of sustainable development, decarbonization, stimulation of green investments, etc. At the same time, the state, through the implementation of environmental innovations, renewable energy sources, environmental management and audit

systems, and the business sector, provides appropriate measures for sustainable environmental policy. Providing information about decarbonization processes and the specifics of implementing alternative energy at the level of individual communities and households, as well as providing them with green credits and benefits, will also contribute to reducing CO₂ emissions. Examples from European countries demonstrate that institutions involving key stakeholders can improve the implementation of such a process at the political level.

(3) Transformation and industrial policy. Sustainable transformation of the energy industry has long-term consequences. This includes the consequences that disproportionately affect territories and populations, the impact of the energy transition on the economy as a whole, and how they can be regulated. What is relevant here is the implementation of a systemic policy on retraining and compensation payments to employees laid off in connection with the transformation policy. Changes in the energy sector will provide a comprehensive set of new opportunities and jobs for the personnel laid off, for example, from coal-based power plants and mines. Another aspect that needs to be taken into account concerns socio-economic issues, in particular the rise in energy prices for end consumers. As this may disproportionately affect vulnerable households and energy-intensive industries, this issue should be given special attention to avoid social hardship. Strategic coordination of industrial and energy sector policies is important here: which areas have been negatively affected; do they remain potentially viable in the future, and how can they be kept internationally competitive? It is recommended to introduce mechanisms for compensation and/or exemption from energy fees and taxes for enterprises in certain energy-intensive industries. It is also extremely important to increase state preferences for electricity productivity and modernization. This will help energy companies compete internationally, and this is especially important for companies that still use outdated technologies and do not receive financing.

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Вищий навчальний заклад "Національна академія управління", Київ, Україна

КЛЮЧОВІ ТЕНДЕНЦІЇ В УПРАВЛІННІ ЕНЕРГЕТИЧНИМ СЕКТОРОМ УКРАЇНИ В КОНТЕКСТІ ВОЄННОЇ АГРЕСІЇ

Вступ. Енергетичний сектор України є критичним компонентом національної інфраструктури. В Україні це питання є особливо актуальним під впливом військової агресії, оскільки відбувається постійне руйнування об'єктів у всіх секторах (від видобувного до генерації електроенергії та нафтопереробки). Відновлення енергетичного сектору України та його подальший розвиток вимагають нових підходів до управління та застосування нових технологій для підвищення ефективності використання ресурсів. Метою дослідження є визначення основних трендів і розроблення підходів до інтенсивного використання енергетичних ресурсів України із застосуванням новітніх технологій. Завданням дослідження є визначення перспектив використання когенерації для відбудови енергетичного сектору України. Об'єкт дослідження – підходи до інтенсивного використання енергетичних ресурсів. Предмет дослідження – основні інструменти для відбудови енергетичного сектору України.

Методи. Методологічною основою дослідження є загальнонаукові та спеціальні методи наукового пізнання, зокрема й теоретико-методологічний аналіз сучасної літератури з питань розбудови енергетичного сектору, документів світових організацій в енергетичній сфері. Метод аналізу та синтезу використано для узагальнення та єдиного підходу до висвітлення переваг і недоліків зазначених інструментів для відбудови енергетичного сектору. Також застосовано SWOT- і PESTEL-аналіз для визначення переваг і недоліків використання когенерації як інструменту відбудови енергетичного сектору України.

Результати. Дослідження показало, що значні руйнування в енергетичному секторі України вимагають застосування нових стратегій його розбудови. Пошкодження об'єктів генерації електроенергії потребують їхнього відновлення на принципах низьковуглецевих технологій, а атаки на родовища нафти та газу призвели до необхідності відновлення попередньо законсервованих джерел вуглеводнів. Визначено, що використання родовищ, що були законсервовані через нерентабельність, вимагає переходу на нові, сучасніші технології, що дасть змогу наростити ресурсну базу вуглеводнів і за допомогою когенерації енергії розв'язати проблему енергонезалежності й екології.

Висновки. Впровадження когенерації в умовах зьогорення і війни дозволить залучити додаткові інвестиції для приросту видобувних запасів нафти і газу, підтримання видобутку вуглеводнів на поточному рівні з метою прирощення виробництва електроенергії, досягнення енергетичної стійкості й автономності, економії палива, зменшення енергетичної залежності країни, забезпечення екологічної безпеки тощо.

Ключові слова: нафта, газ, недіючі родовища, ліквідовані свердловини, нафтогазова галузь, видобуток, когенерація, важковидобуті запаси.

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HOUSEHOLD DEPOSITS AND DEPOSIT GUARANTEE SCHEMES DURING CRISES IN UKRAINE

Background. Ensuring the stability of the banking system remains a key challenge during periods of economic and geopolitical crises. In Ukraine, the deposit guarantee system consists of both explicit and implicit components. While the explicit mechanism is represented by the Deposit Guarantee Fund (DGF), the implicit component reflects household trust in the state's role in protecting deposits, especially during force majeure events. This study aims to evaluate deposit stability in Ukrainian banks during crises.

Methods. The study applies descriptive statistical analysis of deposit trends disaggregated by bank ownership (state-owned, foreign, private) and deposit currency (national vs. foreign) from 2013 to 2024. The analysis includes chain growth rates and deposit structure indicators (demand vs. time deposits) during key crisis phases: the 2014 military aggression, the COVID-19 pandemic, and the 2022 full-scale invasion.

Results. During the analyzed period, the structure of household deposits underwent significant transformations. First, the ratio between time deposits and demand deposits in the national currency declined from 2.63 to 0.52, while in foreign currency it dropped from 6.77 to 0.56. Second, households increasingly favored government-owned banks, while foreign banks retained a moderate level of trust and private banks showed greater volatility. Both explicit and implicit deposit guarantees played a role in maintaining depositor confidence. However, during major shocks, the implicit guarantee system proved particularly influential.

Conclusions. In Ukraine, deposit analysis must consistently account for the currency structure due to persistent devaluation risks and the varying levels of depositor trust associated with different forms of bank ownership. A comprehensive understanding of deposit behavior under stress requires evaluating both explicit and implicit protection. While the DGF offers a solid foundation, it must be supported by credible implicit guarantees and effective crisis management frameworks.

Keywords: deposit insurance schemes, explicit deposit guarantee, implicit deposit guarantee, financial crisis, banking system resilience, foreign banks, government banks.

Background

Ukraine's history of independence following the dissolution of the Soviet Union spans over three decades. During this period, the country's banking system has accumulated experience in managing crises driven by political, economic, and force majeure factors. This experience includes episodes of bank runs as well as the implementation and testing of both implicit (such as restrictions on cash withdrawals and bank nationalization) and explicit deposit insurance systems (notably, the establishment of the DGF in 1998) to prevent and mitigate such runs.

Each episode of a bank run has had its unique causes. The 2004 panic was triggered by political turmoil during the Orange Revolution, while the 2008 panic emerged in response to the Global Financial Crisis. The bank runs of 2014 and 2022, triggered by the Russian military aggression, led to large-scale bank runs and represent unprecedented events in the recent history of the European banking sector. The magnitude and context of these episodes render the Ukrainian case uniquely significant, requiring thorough

scholarly examination. Despite their different origins, all of these crisis events took place under a dual system of financial safety nets: an implicit form (unwritten government support) and an explicit form (formalized insurance schemes). This dual experience is particularly important for analysis, as it highlights the role of guarantee (insurance) schemes in mitigating the effects of bank runs on the stability of the banking system.

The purpose of the study. To assess the impact of force majeure events, particularly the military aggression of the Russian Federation, on the dynamics of household deposits in Ukraine during 2013–2024, both in general and across different groups of banks (government-owned banks (GBs), banks owned by foreign bank groups (FBs), and private banks (PBs)), within the framework of deposit insurance schemes (DISs).

Literature review. A bank run is dangerous not only because "runs are costly and reduce social welfare by interrupting production (when loans are called)" (Diamond, & Dybvig, 1983, p. 403), but also because such panic can

undermine financial stability at the macro level (Kindleberger, 2000). The detrimental consequences of depositors' panic stem from the fundamental nature of banks as financial intermediaries performing transformation functions. In the context of bank runs, maturity and volume transformations are particularly critical, and in countries with weak currencies, currency transformation becomes an additional vulnerability. In its simplest form, a bank's business model involves attracting short- or medium-term retail deposits, typically in small amounts, and allocating them to medium- and long-term loans and investments. A bank run places banks in a vulnerable position due to this inherent mismatch.

One of the earliest responses to mitigating depositor panic was the implementation of bank holidays (Silber, 2009), whereby banks temporarily ceased operations to curb mass deposit withdrawals. This measure proved relatively effective in the short term. However, the practice did not become widespread: out of 147 banking crises that occurred between 1970 and 2011, bank holidays were implemented in only seven cases (DeSilver, 2015). While such an intervention could indeed halt panic in the short term, it clearly did not contribute to building trust or enhancing long-term financial stability. Moreover, as previously discussed, bank holidays represent a reactive measure rather than a preventive one. Therefore, the use of tools that could proactively prevent depositor panic appears more logical. Deposit insurance has emerged as one such preventive solution.

The phenomenon of bank runs and the preventive role of deposit insurance have been the subject of scholarly inquiry for several decades. Nonetheless, certain landmark studies have profoundly influenced the trajectory of this research agenda. Among them, the model proposed by Diamond and Dybvig (1983) is particularly noteworthy for providing a theoretical foundation for understanding banks as financial intermediaries. It formalized the mechanics of depositor panic and demonstrated that the introduction of explicit deposit insurance schemes (EDISs) can serve as an effective mechanism to prevent bank runs. At the time of their publication, EDISs had been adopted in only 19 countries globally (Demirgüç-Kunt, Karacaovili, & Laeven, 2005). By contrast, as of the end of 2023, more than 100 countries had implemented such schemes, according to the International Association of Deposit Insurers (IADI, 2024). The United States pioneered the introduction of EDISs in 1934 in response to the systemic failures of the banking sector during the Great Depression.

The widespread adoption of EDISs has sparked academic debate regarding their comparative effectiveness vis-à-vis implicit deposit guarantees. Implicit deposit guarantees (*de facto*) refer to the expectation that the government will protect depositors, even beyond the limits or scope of explicit (*de jure*) deposit insurance, especially during systemic financial distress, for instance, through bailouts or the introduction of full (100%) deposit guarantees. On the one hand, empirical evidence suggests that deposit insurance can enhance financial stability and promote the development of financial markets (Virchenko, 2008). On the other hand, experience has shown that the existence of an EDIS is not, in itself, a sufficient *ex ante* solution to the problem of depositor panic. This was clearly demonstrated during the Global Financial Crisis, when bank runs occurred even in countries with well-developed banking systems, established deposit insurance schemes, and relatively high levels of financial literacy among the population. A striking example is the case of Northern

Rock, the United Kingdom's fifth-largest mortgage lender, which in mid-September 2007 "...experienced an old-fashioned bank run, where depositors formed long queues in front of its branches to withdraw their money. This marks the first bank run in the UK since the collapse of City of Glasgow Bank in 1878. Eventually, the run had been contained by the bailout announcement of the government that guaranteed all deposits in Northern Rock" (Yorulmazer, 2009, p. 1). Nevertheless, within three days, approximately £3 billion had been withdrawn (Stringer, 2007). Consequently, academic inquiry has increasingly focused on the causes of EDISs inefficiencies and potential remedies (McCoy, 2008; Demirgüç-Kunt, Kane, & Laeven, 2015; Pernell, & Jung, 2024). These two strands of – research evaluation of EDISs limitations and exploration of design improvements – should be viewed as complementary. Understanding the sources of EDIS shortcomings opens new perspectives for addressing systemic vulnerabilities. It is also important to note that the effectiveness of explicit deposit insurance is closely intertwined with the issues of moral hazard and market discipline.

In deposit insurance, moral hazard arises in two key ways. Firstly, when deposit insurance is explicitly provided, insured banks may be encouraged to engage in riskier activities, as they stand to benefit from potential profits while transferring any financial losses to the government. Secondly, EDISs diminish the motivation of both depositors and shareholders to oversee the financial health of their banks, as their funds are perceived to be safeguarded regardless of the institution's risk exposure (McCoy, 2008; Allen et al., 2015; Pernell, & Jung, 2024). However, the issue of moral hazard can be mitigated when the economy demonstrates stable growth and when the systems of banking supervision and deposit insurance operate effectively. In this context, not only the regulatory environment but also institutional trust in the financial system plays a critical role. In Ukraine, institutional factors – particularly the perceived reliability of financial institutions and the level of public trust in them – have a significant impact on the volume of household bank deposits (Grazhevskaya, & Shemakhina, 2018). This underscores that the effective functioning of a financial safety net is unattainable without a robust institutional framework capable of supporting the sustainable development of the banking sector, even under crisis conditions.

The distinction between market discipline and moral hazard lies in the fact that, even under explicit deposit insurance schemes (EDISs), depositors tend to demand higher interest rates from banks they perceive as engaging in riskier activities (Quintero-V, 2023). As McCoy (2008, p. 430) observes, "In the United States, evidence shows that uninsured depositors do demand higher returns on their accounts".

Therefore, it becomes evident that while EDISs may reduce the likelihood of bank runs, they do not eliminate this risk. The following sections of this paper will explore whether EDISs remain effective under force majeure conditions, drawing on evidence from crisis episodes in Ukraine.

Methods

To achieve the objective of this research, a series of statistical methods was employed.

First, descriptive statistics were applied to analyze the overall trends in household deposit volumes and interest rates in the banking sector in Ukraine over the period 2013–2024, based on official data from the National Bank of Ukraine (NBU).

For a more precise analysis, these changes were examined according to specific characteristics, which

enabled the identification of distinct patterns in the dynamics across different groups.

1. The analysis was conducted separately for deposits in the national currency (hryvnia) and foreign currency. Foreign currency deposits were converted to U.S. dollars using the NBU's official exchange rate for the corresponding date.

2. Through the application of data aggregation and classification methods, two primary categories of household deposits (time deposits [TDs] and demand deposits [DDs]) were identified. This distinction enabled the assessment of depositor trust in the banking sector during various crisis periods. The analysis included the dynamics of deposit volumes, the ratio between deposit types, and chain growth rates to capture behavioral shifts in depositors' preferences.

3. A comparative analysis was conducted across government-owned banks (GBs), foreign-owned banks (FBs), and privately owned banks (PBs) to identify peculiarities in depositors' trust. Given the significant changes in bank ownership structures throughout the study period, the classification of banks by ownership was fixed as of February 1, 2022. This approach was adopted to ensure analytical consistency and avoid distortions arising from transitional forms of ownership, short-term statuses, or institutional reorganizations such as nationalizations and bankruptcies. Fixing the ownership status on a specific date provides a more stable analytical framework and mitigates the risk of drawing erroneous conclusions.

Second, indicators of deposit variation were calculated to evaluate the level of (in)stability of deposits in each group of banks.

Third, a periodization of crisis events was also applied based on historical and political facts that were accompanied by bank runs.

The generalization of results was carried out taking into account the conceptual approach to the interaction between moral hazard and market discipline under EDISs, as well as the historical development of the Deposit Guarantee Fund (DGF) in Ukraine.

Results

Deposit insurance in Ukraine. Deposit insurance is a fundamental component of the financial safety net and is closely related to both market discipline and moral hazard (Quintero-V, 2023). In particular, implicit deposit insurance can exacerbate moral hazard, as banks may engage in excessive risk-taking in anticipation of government bailouts during times of instability. Similarly, depositors may be willing to take higher risks in the expectation of government intervention. Moreover, implicit deposit insurance weakens market discipline, as both investors and depositors know that implicit guarantees reduce their exposure to potential losses.

Explicit deposit insurance can also contribute to moral hazard, as banks may take additional risks on the assumption that insured deposits minimize the potential financial impact. However, unlike its implicit counterpart, EDISs are underpinned by market discipline – if properly designed, they include regulatory oversight and risk-adjusted premiums that help to discourage excessive risk-taking. Well-structured EDISs are crucial in preventing bank runs and reducing systemic panic **thereby** enhancing overall financial stability. However, if they are poorly structured, such as through flat-rate premiums or unlimited coverage, they can still incentivize excessive risk-taking and ultimately undermine their stabilizing role (Fig. 1).

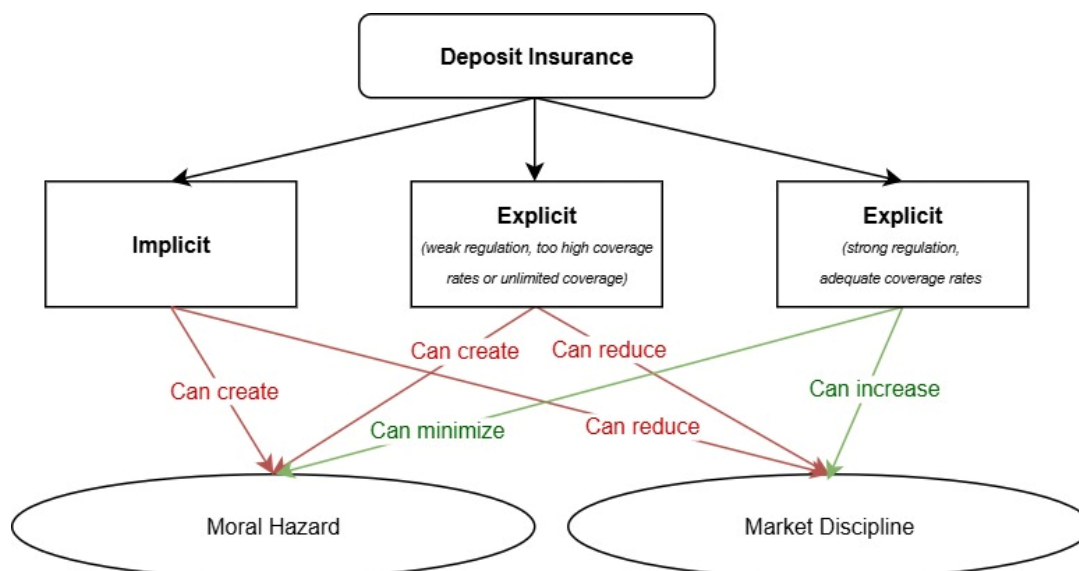


Fig. 1. Conceptual framework of explicit and implicit deposit insurance correspondence with moral hazard & market discipline
Source: authors' development based on (Financial Stability Forum, 2001).

The effectiveness of EDISs in preventing bank runs is contingent upon preserving market discipline – that is, depositors must continue to evaluate banks based on their risk-return tradeoffs rather than relying solely on insurance coverage. Explicit deposit insurance coverage includes types of financial institutions under the "umbrella" deposit types that are insured, and the coverage limit. In other words, the coverage must be optimally designed to balance financial stability and depositor incentives. If the coverage is

insufficient, the positive effects of EDISs in mitigating bank runs during periods of financial instability may be weakened. Conversely, if the coverage is too broad and the coverage limit is excessively high, depositors may lose the incentive to assess bank risk, undermining market discipline. This is why full deposit insurance (100% coverage) should remain an exceptional measure, implemented only under specific circumstances, even in times of crisis. For instance, extraordinary interventions – such as those prompted by the

war in Ukraine – may necessitate temporary full guarantees to maintain public confidence. Similarly, in cases where banks remain fundamentally stable during a financial crisis, but depositor panic threatens systemic stability, full deposit guarantees may serve as a necessary safeguard.

Deposit insurance in Ukraine was introduced in 1998 with the establishment of the DGF (Verkhovna Rada of Ukraine, 1998). The historical context of Ukraine plays a particularly important role in this matter. Ukraine's independence in 1991 was accompanied by unprecedented developments: the freezing of bank deposits, a sharp decline in GDP, hyperinflation, and, as a consequence, skyrocketing financial dollarization (Versal, & Stavtysky, 2016). All deposits placed before January 2, 1992, in branches of the Savings Bank of the USSR operating in Ukraine were frozen. According to the Law of Ukraine "On State Guarantee of Restoring the Savings of Ukrainian Citizens," it was established that "citizens' savings... shall be restored at a rate of 1 karbovanets of savings to 1.05 hryvnia as of October 1, 1996" (Verkhovna Rada of Ukraine, 1996). However, it is important to consider that these funds were severely devalued due to hyperinflation, which peaked in 1993, when the annual chain inflation index for the consumer market reached 10,256% (Yushchenko, 1995, p. 3). Moreover, the return of these funds always depended on the availability of corresponding expenditures in the State Budget of Ukraine, since "savings are repaid gradually, depending on the deposit amount and within the limits of funds allocated for this purpose in the State Budget of Ukraine for the current year" (Verkhovna Rada of Ukraine, 1996). Therefore, in the early years of Ukraine's independence, newly established banks faced significant difficulties in attracting household deposits. A return of deposits to Ukrainian banks began only after the monetary reform of 1996, the establishment of the DGF in 1998, and an increase in income and household welfare.

In this study, the main milestones in the development of the DGF and the episodes of bank runs in Ukraine from 1998 to 2024 are presented. Among the identified episodes of bank runs, only the 2008–2009 Global Financial Crisis was driven exclusively by economic factors. All other bank runs were primarily triggered by political or force majeure events. The first politically induced bank run occurred in 2004 during the Orange Revolution, which began on November 22, 2004, and ended with the inauguration of President Viktor Yushchenko on January 23, 2005. Deposit outflows were observed throughout this period, with household deposit balances declining from UAH 45,080 million in October 2004 to UAH 42,878 million in November, UAH 41,611 million in December, and partially recovering to UAH 44,252 million by January 2005 (National Bank of Ukraine, 2005a, p. 98; National Bank of Ukraine, 2005b, p. 94). A similar dynamic was observed during the 2013–2014 Euromaidan protests (Revolution of Dignity) and the subsequent military aggression by the Russian Federation against Ukraine (Versal, 2019). The most recent and largest-scale depositor panic occurred in response to the full-scale invasion of Ukraine by the Russian Federation on February 24, 2022.

Another force majeure event that warrants attention is the COVID-19 pandemic. This period was marked by its extraordinary nature, which logically led to expectations of at least a moderate outflow of deposits. However, an analysis of official statistical data revealed no evidence of such an outflow, suggesting the absence of depositor panic during this time. On the contrary, in relative terms, the volume of DDs in foreign currency increased by 36% over the first two quarters of 2020 compared to the beginning of

the year, amounting to UAH 24.7 billion in hryvnia equivalent. DDs in national currency rose by UAH 41.6 billion (+28.3%) over the same period.

As for TDs, growth was observed only in national currency, albeit at a more modest rate – an increase of 5%, or UAH 8.4 billion, over the two first quarters of 2020. At the same time, TDs in foreign currency recorded a slight decline of 0.5%, equivalent to UAH 0.9 billion.

This situation may have at least two possible explanations. First, the nature of the crisis may have resembled the effects of a bank holiday, as discussed in the introductory section of the study. Second, if there was a short-term outflow of funds, its duration was so limited that the banking system did not capture it in the quarterly statistics.

Although the causes of bank runs in 2008 and from 2013 onward were fundamentally different, it is important to highlight the effectiveness of government regulatory responses. This experience later proved valuable in 2022. In 2008, the Speaker of the Verkhovna Rada supported the adoption of Resolution No. 319 of the NBU Board, titled "On Additional Measures Regarding the Activities of Banks" (RBC-Ukraine, 2008). This resolution aimed to stabilize the banking system and the foreign exchange rate of the national currency. However, these were temporary regulatory interventions, typical of crisis response frameworks, rather than structural legislative reforms. The key measures implemented to prevent depositor panic included the following:

- "In the event of a decrease in the volume of time deposits in a bank by 2% over five business days, the bank may apply to the National Bank of Ukraine for emergency liquidity support in an amount up to 60% of the bank's statutory capital for a period of up to one year, at a rate of 15%, provided that a duly executed pledge agreement is submitted simultaneously, securing shares/interests in the bank that together represent at least 51% of the statutory capital or voting rights of the acquired shares/interests in the bank, with the National Bank of Ukraine designated as the beneficiary (pledgee)." However, such support was only available to banks "organized in the form of public joint-stock companies with a paid-up statutory capital of at least UAH 500 million" (Verkhovna Rada of Ukraine, 2008).

- "Fulfill obligations under all types of fund-raising agreements in any currency only upon the maturity of such obligations" (Verkhovna Rada of Ukraine, 2008).

Systemic changes occurred with the adoption of the Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine Regarding the Conditions for the Return of Term Deposits" (Verkhovna Rada of Ukraine, 2015b), which amended the Civil Code of Ukraine:

- "Under a demand deposit agreement, the bank is obliged to return the deposit or a part thereof upon the depositor's first request. Any clause in a demand deposit agreement that waives the depositor's right to withdraw the deposit upon request is deemed null and void" (Verkhovna Rada of Ukraine, 2015a).

- "Under a fixed-time deposit agreement, the bank is obliged to return the deposit and the interest accrued on it upon the expiration of the term specified in the deposit agreement. Early withdrawal of the fixed-time deposit and the accrued interest at the depositor's request – before the expiration of the term or the occurrence of other conditions specified in the agreement – is allowed only if such an option is explicitly stipulated in the terms of the fixed-time deposit agreement" (Verkhovna Rada of Ukraine, 2015a).

These legislative changes significantly enhanced the legal certainty regarding the fixed-time nature of deposits and limited the possibility of early withdrawal of funds at the depositor's initiative. As a result, a clear distinction between TDs and DDs was established, which contributed to improving the predictability of liquidity within the banking system.

It can be argued that this prior experience formed the basis for an effective response to the full-scale invasion of Ukraine by the Russian Federation on February 24, 2022. On the very first day, the National Bank of Ukraine adopted Resolution No. 18 "On the Operation of the Banking System During the Period of Martial Law" (Verkhovna Rada of Ukraine, 2022b), which included several provisions specifically related to bank deposits in the Ukrainian banking sector:

- A limit on cash withdrawals from client accounts, capped at UAH 100,000 per day. This measure aimed to reduce the risk of panic-driven withdrawals by depositors under crisis conditions and to stabilize the liquidity of the banking system (Verkhovna Rada of Ukraine, 2022b).

- A ban on cash withdrawals in foreign currency from client accounts (with exceptions for operations related to mobilization tasks, government payments, and specific permits issued by the NBU). This restriction was aimed at curbing the outflow of foreign currency deposits (Verkhovna Rada of Ukraine, 2022b).

- Non-cash transactions were allowed without restrictions. This measure supported trust in the banking system and ensured the continued functionality of financial operations under conditions of limited access to cash (Verkhovna Rada of Ukraine, 2022b).

- Cash replenishment of bank branches was carried out without restrictions.

- Bank branches were required to continue operating without interruption, as long as there was no immediate danger to the lives or health of people. This measure was necessary to ensure that people could still access essential banking services (Verkhovna Rada of Ukraine, 2022b).

During the study period, the deposit guarantee system in Ukraine underwent significant transformations, which are illustrated in the timeline (Fig. 2). Initially, until 2012, the DGF operated with a limited mandate and functioned as a pay-box, meaning it solely performed the function of compensating depositors of liquidated banks. The adoption of the Law of Ukraine "On the System of Guaranteeing Natural Person Deposits" on February 23, 2012, granted the Fund expanded powers, elevating its status to that of a loss-minimizer, according to the International Association of Deposit Insurers (IADI) classification (Verkhovna Rada of Ukraine, 2012).

As a loss-minimizer, the DGF actively engages in minimizing losses during bank resolution processes, asset sales, and the satisfaction of depositors' claims. Further milestones included the expansion of the list of eligible depositors through the inclusion of individual entrepreneurs in 2015, as well as systemic changes in 2022: the inclusion of JSC Oschadbank in the guarantee system (i.e., the only major government-owned bank in Ukraine that, until its inclusion in the deposit guarantee system, operated under a special legal regime whereby all household deposits were fully guaranteed by the state, without coverage limits), an increase in the maximum guaranteed compensation to UAH 600 000, and the temporary (for the duration of martial law and three months after its termination) introduction of full reimbursement of deposits regardless of the amount.

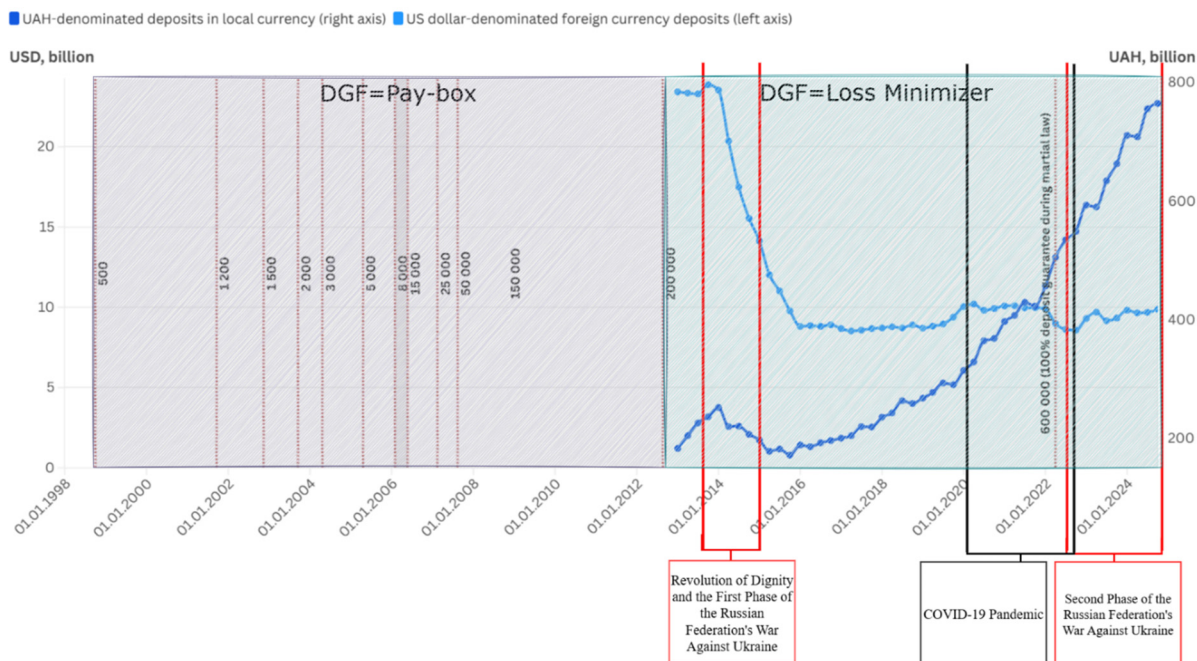


Fig. 2. Transformation of the Deposit Guarantee System and dynamics of household bank deposits in Ukraine during crisis periods (January 1, 1998 – October 1, 2024)

Source: compiled based on (Malafieiev, & Lykhobabina, 2017; National Bank of Ukraine, 2024a; Verkhovna Rada of Ukraine, 2022a; Verkhovna Rada of Ukraine, 2022b).

Banking Specificities in Ukraine, 2012–Q2 2024. Two key transformation functions conducted by banks increase their vulnerability during periods of bank runs. First, maturity transformation: when short-term deposits (mostly under one year) are used to fund medium- and long-term loans.

Second, currency transformation results from persistently high levels of financial dollarization, with foreign currency deposits accounting for 30% to 50% of total deposits over the reviewed period (Fig. 3) (IMF, 2024).



Fig. 3. Trends in selected indicators of the ukrainian banking sector, 2012–Q2 2024

Source: compiled based on (IMF, 2025).

Figure 3 illustrates three key periods for the Ukrainian banking sector: (1) the first phase of the Russian Federation's military aggression against Ukraine, including the annexation of Crimea and the occupation of parts of the Luhansk and Donetsk regions, along with the deep banking crisis of 2014–2017; (2) the COVID-19 pandemic period of 2020–2021; and (3) the ongoing second phase of the full-scale invasion that began on February 24, 2022.

First and foremost, it is important to highlight the generally sufficient capitalization level of Ukrainian banks, which remained above 10% even during the most critical periods. The most challenging phase occurred between 2014 and 2016, when a large number of banks were removed from the market. Specifically, the number of operating banks declined from 180 on January 1, 2014, to 163 in 2015, 117 in 2016, 96 in 2017, and 82 in 2018. As of December 1, 2024, the Ukrainian banking market consisted of only 62 institutions: 7 state-owned banks (accounting for 55.99% of total banking assets), 14 banks affiliated with foreign banking groups (24.70%), and 41 other banks (19.31%) (National Bank of Ukraine, 2024a).

With regard to non-performing loans (NPLs), their peak coincided with the end of the banking crisis in 2017, reaching over 54% of the total loan portfolio. Some of the highest levels of NPLs were recorded in GBs, largely due to the nationalization of Ukraine's largest bank, PrivatBank. Under current conditions, the situation has not undergone fundamental changes. As of early 2023, approximately 75% of the sector's NPLs were concentrated in GBs, with PrivatBank alone accounting for over 40% (National Bank of Ukraine, 2023). This fact is of particular importance, as will be demonstrated later in the study: despite the high level of credit risk in GBs, public trust in these institutions remains strong. This raises questions about the existence of effective market discipline in Ukraine's banking sector, especially in the context of household deposit behavior.

Deposit and loan dollarization in the banking sector has demonstrated a clear downward trend. From peak levels

exceeding 55% during the first phase of the war, dollarization has gradually declined to below 40%. While this trend persisted during the COVID-19 pandemic, both the first and second phases of the military invasion were accompanied by noticeable spikes in financial dollarization. In the first year of each invasion, the increase was nearly identical: +6 percentage points in 2014 and +5 percentage points in 2022.

However, the subsequent behavior of depositors differed significantly. This is an important observation, as Ukrainian households have traditionally shifted their savings into foreign currency during periods of instability. Thus, during the first invasion, the growth of deposit dollarization continued. In contrast, during the second invasion, deposit dollarization began to decline. This divergence can be attributed to at least two factors. First, the decline in the well-being of households led to the consumption of previously accumulated savings. Second, large-scale migration abroad contributed to the physical transfer of foreign currency assets out of the country.

Another indicator of concern is the deposit-to-loan ratio. On the one hand, its growth during crisis periods can be objectively explained by the contraction of business activity. However, as of the second quarter of 2024, the volume of household deposits alone exceeds the total volume of bank loans by 2.2 times. This implies that banks are allocating these deposits to asset classes other than loans. The primary alternative asset has become government securities. In effect, household deposits are, at least partially, being used to finance Ukraine's resistance to Russian aggression through the purchase of government bonds. The yield on these securities has remained attractive: in May 2024, the maximum annual yield on domestic government bonds reached 17.50% (National Bank of Ukraine, 2024b). This contributes to an unusual dynamic in another key indicator – Return on Equity (ROE), which surpassed 40% in 2024. Additionally, the interest rate spread between lending and deposit rates has widened

significantly, reaching 11.3% in Q2 2024 – the highest value observed over the entire reviewed period.

Overall, the Ukrainian banking sector has demonstrated resilience in the face of severe crises. However, the persistent decline in credit activity and increasing reliance on government securities during wartime pose emerging risks to long-term financial stability, particularly from the perspective of depositors.

Trends in Deposit Volumes in the Banking Sector.

The analysis of household bank deposits considers currency denomination, deposit maturity, and the ownership structure

of banks. This section focuses on the dynamics of deposits denominated in the national currency (hryvnia), which are classified into DDs and TDs. In addition, the time-to-demand deposit ratio is calculated as an indicator reflecting the structure of savings and the level of depositors' confidence in the banking system in terms of liquidity and stability.

1. Hryvnia-Denominated Bank Deposits

To assess the overall trends in deposit activity, the dynamics of hryvnia-denominated deposit volumes and the time-to-demand deposit ratio across the Ukrainian banking sector were analyzed (Fig. 4).

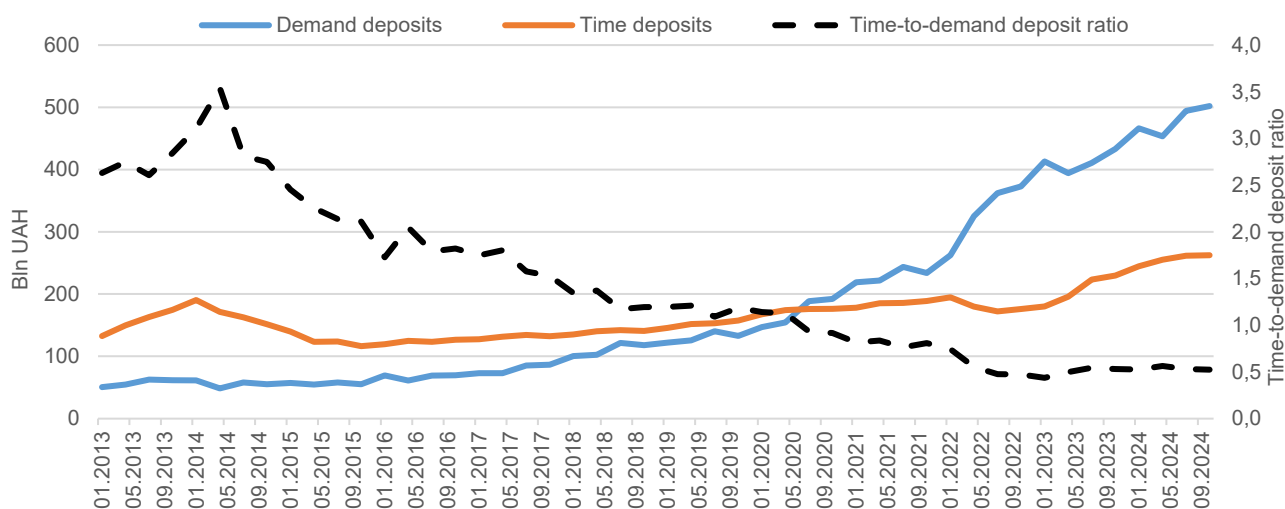


Fig. 4. Trends in UAH-denominated deposits (left axis, UAH million) and the time-to-demand deposit ratio (right axis) in the Ukrainian banking sector from January 2013 to October 2024 (all banks included)

Source: compiled based on (National Bank of Ukraine, 2024a).

As shown in Fig. 4, several trends can be identified that correspond to key historical events:

- Before January 2014, there was a sharp increase in TDs (in January 2014, compared to January 2013, TDs increased by 43.8%), but the volume of DDs increased only by 21.8%. The time-to-demand deposit ratio in January 2014 was 3.1:1 compared to 2.6:1 in January 2013. This indicated growing trust in the banking system and the accumulation of credit potential by banks.

- The annexation of Crimea in 2014 disrupted historical trends. A withdrawal of deposits from banks began, with the pace of outflow being significantly higher for TDs than for DDs. While the decline in DDs was short-term (observed in April 2014 and followed by a recovery), the outflow of TDs did not cease until October 2015. The accumulation of TDs began to slow, while more funds were concentrated in DDs. By January 2020, compared to April 2014, the volume of DDs had increased by 203.5%, whereas TDs had decreased by 2.2%. The time-to-demand deposit ratio fell by 67.8%. These trends reflect uncertainty - there was no panic-driven withdrawal, but trust in long-term deposits remained low.

- The COVID-19 pandemic had an impact on the banking system but did not reverse existing trends; rather, it reinforced them. As of July 2020, the DD increased by 65.7% compared to January 2020, and TDs grew by 10.9%. Although the pandemic did not produce a shock comparable to that of Crimea's annexation in 2014, the trends that emerged during that earlier crisis continued. Trust in long-term deposits did not recover, and most household funds remained in DDs.

- Since the beginning of the full-scale invasion, trends in demand and time deposits have diverged. While DDs continued to grow (indicating no apparent outflow of funds), TDs declined until July 2022 – possibly reflecting a shift from TDs to DDs. However, despite the overall positive dynamics in both categories, it is important to note that the time-to-demand deposit ratio that qualitatively characterizes the structure of deposits continued to deteriorate.

It is important to recall that on 14 May 2015, amendments to the Civil Code of Ukraine were adopted, prohibiting the early withdrawal of TDs (Verkhovna Rada of Ukraine, 2015b). Although it is not possible to definitively isolate the effects of this legislative change – given the presence of numerous other factors negatively affecting deposit volumes in the Ukrainian banking sector – the empirical evidence suggests that it did not produce a significant adverse impact on the dynamics of TDs. Both hryvnia- and foreign currency-denominated TDs demonstrated positive growth rates as early as 2016.

This study pays particular attention to the analysis of deposit interest rate trends, which serve as a critical indicator of the attractiveness of banking deposits under economic instability. The analysis covers the period from January 2013 to October 2024 and disaggregates the data by currency (hryvnia, US dollar) and two deposit tenures: 3 months (representing short-term placements, approximately equivalent to demand deposits) and 12 months (the longest maturity most commonly offered by banks).

The dynamics of interest rates on hryvnia- and US dollar-denominated deposits between 2013 and 2024 exhibit distinct fluctuations corresponding to key crisis periods in

Ukraine. During the banking crisis and the annexation of Crimea (2014–2016), there was a significant increase in hryvnia deposit rates, particularly for 12-month term deposits, which peaked at over 22%. At the same time, US dollar deposit rates also rose but remained within the 8–10% range. This indicates that banks sought to compensate for rising risk levels and retain their funding base.

In March 2020, at the onset of the COVID-19 pandemic, there was no marked increase in deposit rates, which may suggest the absence of a sharp decline in public trust in the banking system – unlike during the previous crisis. Throughout this period, short-term rates consistently remained lower than long-term rates.

Following the full-scale invasion by the Russian Federation in February 2022, interest rates initially declined sharply. However, as during previous crises, a subsequent increase was observed, particularly in hryvnia-denominated 12-month deposits, which exceeded 20% by mid-2023. This surge likely reflects banks' efforts to attract long-term funding. In contrast, interest rates on US dollar deposits remained largely stable throughout the entire period under review, suggesting a lack of interest from banks in foreign currency deposits, mainly due to regulatory restrictions on open foreign exchange positions (Fig. 5).

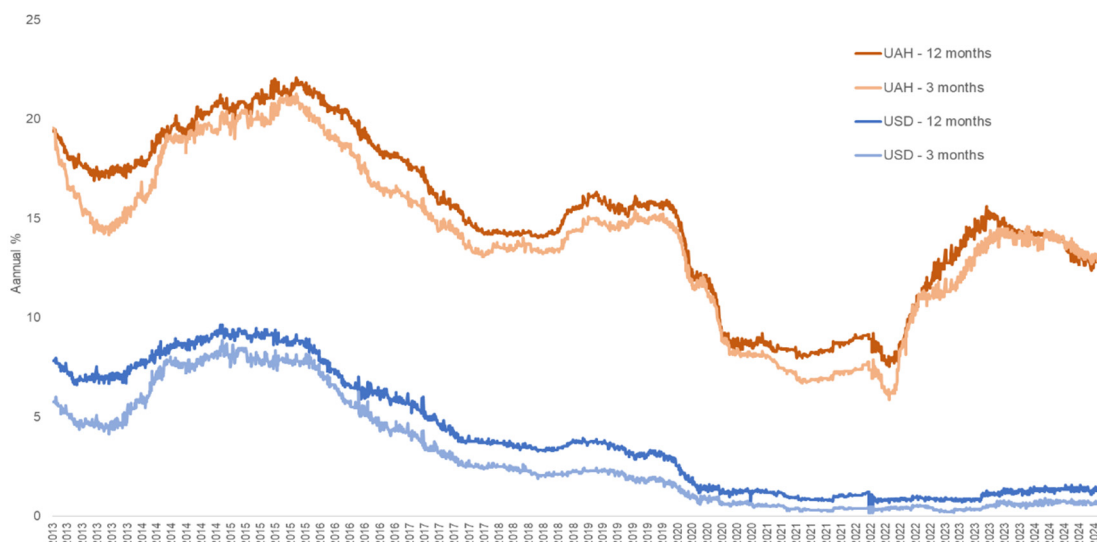


Fig. 5. Trends in interest rates on 3-month and 12-month UAH and USD deposits, January 2013–October 2024

Source: compiled based on (National Bank of Ukraine, 2025a).

The dynamics of the interest rate gap for hryvnia and US dollar deposits indicate significant shifts in banks' and depositors' expectations regarding the maturity structure of resources during crisis periods (Fig. 6). In particular, during episodes of heightened macro-financial turbulence, the gap between interest rates on hryvnia deposits narrowed, at times becoming negative when the rates on 3-month deposits exceeded those on 12-month deposits. This inversion of the yield curve is indicative of elevated uncertainty and rising short-term risks. In fact, a negative interest rate gap or its convergence toward zero can be

interpreted as a signal of a crisis scenario unfolding, or at least the anticipation of such a scenario by market participants. A likely explanation for this inversion is the increased demand for short-term liquidity by banks, which also serves as an indirect indicator of financial instability.

In contrast, the consistently positive gap for US dollar deposits throughout the entire study period may reflect more stable expectations, lower volatility, and the influence of external (global) factors that limit the responsiveness of interest rates in the foreign currency segment.

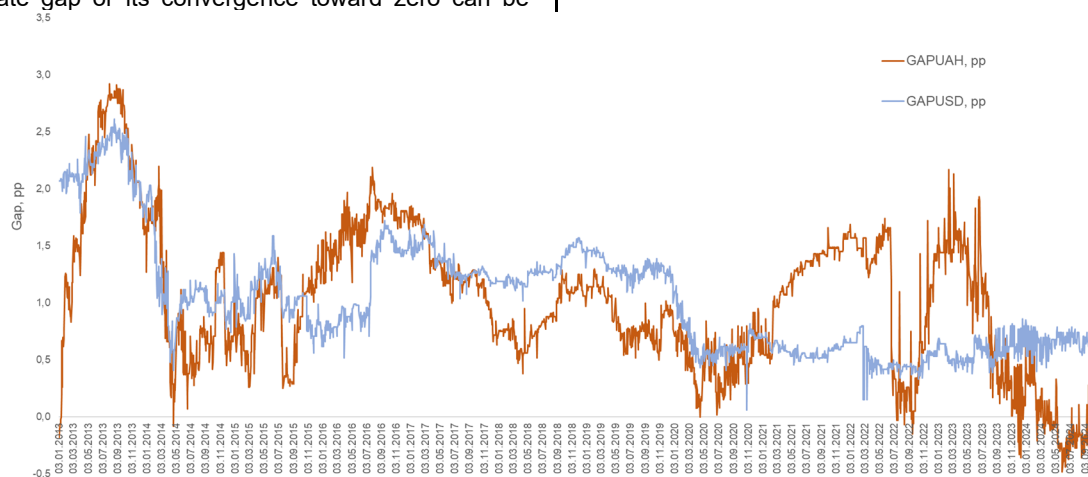


Fig. 6. Trends in interest rate gaps between 3-month and 12-month UAH and USD deposits, January 2013 – October 2024
Source: compiled based on (National Bank of Ukraine, 2025a).

2. Foreign Currency Denominated Bank Deposits

The dynamics of foreign currency deposits differed from those of hryvnia deposits (Fig. 7):

- The negative impact of the events of 2014 on the dynamics of TDs in foreign currency is evident. Between January 2013 and October 2015, the volume of TDs dropped by more than 2.5-fold. At the same time, there was no corresponding shift of funds into DDs, indicating a significant withdrawal of savings from the banking system. This may have been driven either by a rise in depositor distrust or by direct losses resulting from the mass bankruptcy of banks: 33 banks were withdrawn from the market in 2014, followed by another 32 in 2015 (National Bank of Ukraine, 2025b).

- The share of DDs in the structure of foreign currency deposits remained relatively stable during 2014–2017, indicating no significant changes in depositor behavior during this period. However, since 2019, a clear upward trend in DDs has been observed, which was further reinforced by the COVID-19 pandemic. Although the response from depositors was delayed, the effect of the pandemic on foreign currency deposits became evident approximately one year later compared to UAH deposits.

- A key turning point in the dynamics of foreign currency deposits was the moment when the volume of DDs exceeded that of TDs. This structural shift in depositor behavior may reflect deepening mistrust in long-term savings in banks, a growing preference for liquidity, and an increased level of uncertainty in the financial decision-

making environment. In this context, the growth of DDs is not only a consequence of the declining attractiveness of long-term deposits due to near-zero interest rates but also a manifestation of adaptive behavior by the population in the face of economic and geopolitical instability.

- The ratio of term foreign currency deposits to demand deposits has shown a steady downward trend throughout the entire observation period. In January 2014, its value stood at 7.9, but by April 2015, it had already declined to 3.9. A brief stabilization followed, lasting until 2017, after which the downward trend resumed, reaching 0.56 in October 2024. This dynamic indicates profound shifts in depositor behavior and may be considered critical, given the traditional role of foreign currency in Ukraine as a means of saving. During times of uncertainty and financial turbulence, there has been a clear shift away from term instruments in favor of more liquid forms of holding funds. This transformation can be explained by at least three factors. First, the likely withdrawal of foreign currency savings from the banking system for "under-the-mattress" storage, which is a typical reaction during periods of perceived threats to the banking sector. Second, the relocation of funds abroad and migration processes triggered by the full-scale war may have led to the redirection of savings for current use in other jurisdictions, including deposit placement in banks of host countries. Third, the impoverishment of the population due to the economic crisis, loss of income, and inflationary pressure resulted in the fragmentation of the deposit base and the use of previously accumulated foreign currency savings to cover basic needs.

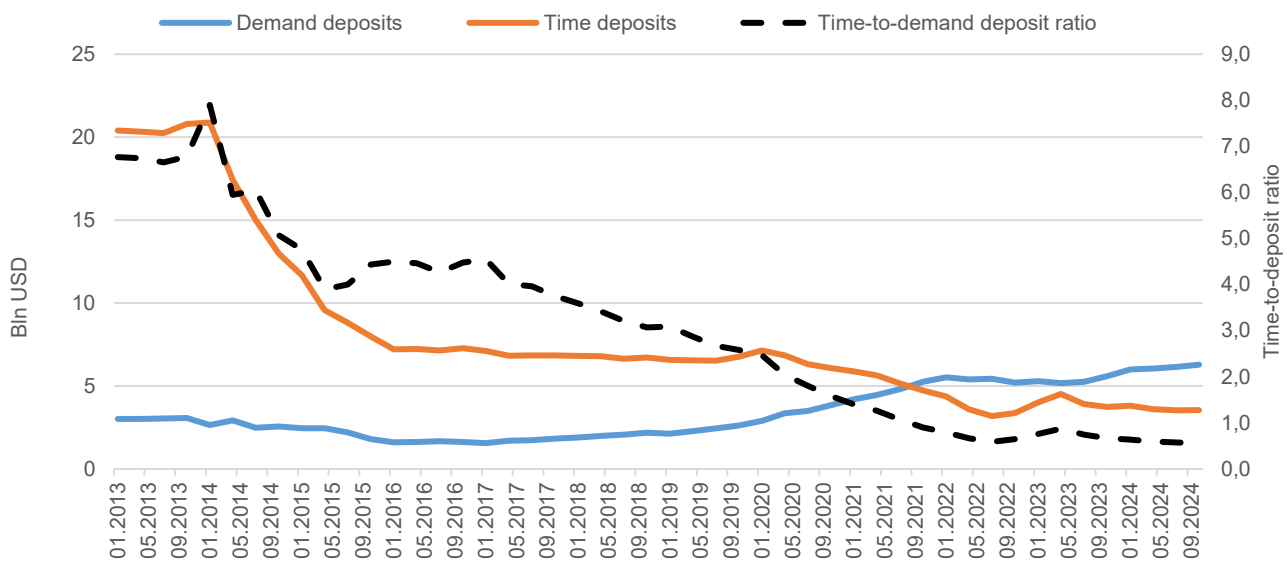


Fig. 7. Trends of foreign currency deposits (left axis) and time-to-demand deposit ratio (right axis) in the Ukrainian banking sector, January 2013 – April 2024 (all banks included)

Source: compiled based on (National Bank of Ukraine, 2024a).

3. National currency-denominated deposits vs. foreign currency-denominated deposits in times of crises

The data presented in Table 1 clearly illustrate the differences in the dynamics of hryvnia and foreign currency deposits under the influence of crisis events, particularly the war and the COVID-19 pandemic. A fundamentally different sensitivity of savings is observed depending on the currency of the deposit and its maturity. While DDs in foreign currency tend to recover relatively quickly even during crises, TDs in foreign currency exhibit high vulnerability and a tendency to decline sharply.

Between 2013 and 2024, the structure of hryvnia deposits underwent significant changes. Overall, the volume of DDs increased by 897.4%, while TDs grew by only 98.3%. The ratio of time-to-demand deposits (TDs/DDs) dropped more than fivefold, from 2.6 in 2013 to 0.5 in 2024, indicating a growing preference for liquidity.

DDs in UAH dropped during the first quarter of 2014 by 21.1%, while TDs declined by 10.1%. However, in 2022, depositor behavior was different: DDs increased by 23.9% in the first quarter, with only a minor outflow of TDs (7.6%). During the COVID-19 pandemic, DDs and TDs increased.

Table 1

Changes in hryvnia and foreign currency deposits in the Ukrainian banking sector during crisis periods (all banks included)

Date	UAH deposits, bln UAH			Chain growth rate, %			FC deposits, bln USD			Chain growth rate, %		
	DD	TD	TD/DD	DD	TD	TD/DD	DD	TD	TD/DD	DD	TD	TD/DD
01.2013	50.35	132.41	2.6	-	-	-	3.01	20.40	6.8	-	-	-
07.2013	62.55	163.05	2.6	24.2	23.1	-0.9	3.04	20.25	6.7	1.0	-0.7	-1.7
01.2014	61.31	190.44	3.1	-2.0	16.8	19.2	2.64	20.88	7.9	-13.2	3.1	18.8
04.2014	48.39	171.25	3.5	-21.1	-10.1	13.9	2.93	17.43	5.9	10.9	-16.5	-24.7
01.2020	146.89	167.43	1.1	203.5	-2.2	-67.8	2.89	7.14	2.5	-1.2	-59.0	-58.5
07.2020	188.51	175.85	0.9	28.3	5.0	-18.2	3.50	6.31	1.8	20.8	-11.7	-26.9
01.2022	262.32	194.64	0.7	39.2	10.7	-20.5	5.52	4.38	0.8	57.8	-30.7	-56.1
04.2022	325.14	179.77	0.6	23.9	-7.6	-25.5	5.40	3.59	0.7	-2.2	-17.9	-16.1
07.2022	494.16	261.46	0.5	52.0	45.4	-4.3	6.15	3.54	0.6	13.9	-1.5	-13.5
10.2024	502.17	262.53	0.5	1.6	0.4	-1.2	6.29	3.54	0.6	2.3	0.2	-2.0
Total	X	x	x	897.4	98.3	-80.1	x	x	x	108.6	-82.6	-91.7

Source: calculated by authors based on (National Bank of Ukraine, 2024a).

A completely different situation is observed with foreign currency deposits. At the onset of the war in 2014, TDs in foreign currency declined from USD 20.88 billion in January 2014 to USD 17.43 billion in April 2014 (-16.5%), while DDs slightly increased over the same period (+10.9%). During the first quarter following the full-scale invasion in 2022, DDs decreased by 2.2%, while TDs dropped by 17.9%. During the COVID-19 pandemic, in July 2020, TDs fell by 11.7% compared to the previous period, whereas DDs rose by 20.8%. The ratio of TDs to DDs dropped significantly – from 6.8 in January 2013 to only 0.6 in July 2024. This more than 91% reduction signals a major structural shift in depositor behavior in favor of liquidity and short-term savings instruments.

A comparison between hryvnia and foreign currency deposits reveals a common trend of declining confidence in

long-term savings, albeit with differing dynamics. First, during the second phase of the war, depositor behavior shifted, possibly due to adaptation and a better understanding of the potential consequences of war. Second, foreign currency deposits proved more sensitive to crises: households tend to hold foreign currency outside the banking system or in current accounts, while hryvnia is primarily kept in liquid savings forms.

4. Coefficient of variation of deposits

The coefficient of variation serves as a relative measure of risk or instability in the process of attracting bank deposits, reflecting the degree of deviation of individual deposit volumes from their average level (Fig. 8).

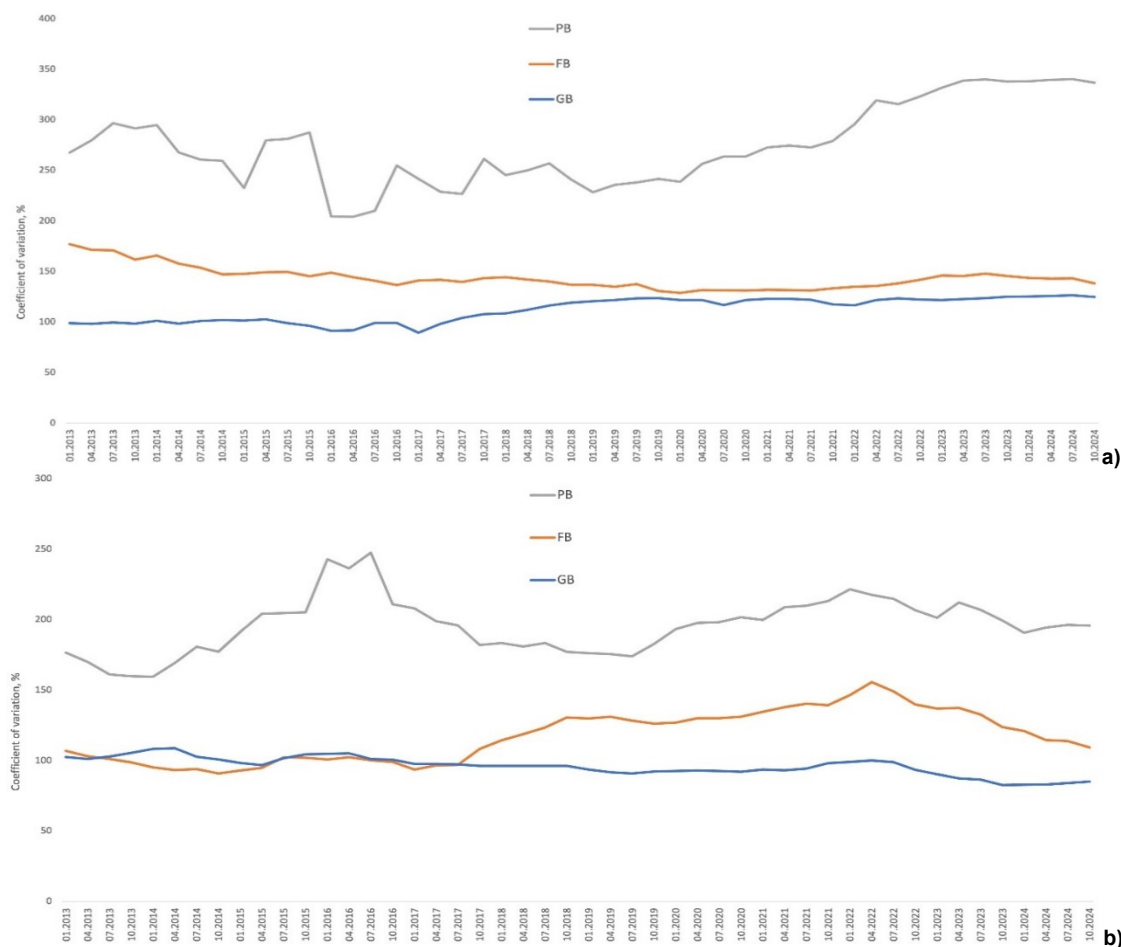


Fig. 8. Coefficient of variation for demand deposits (a) and time deposits (b) in UAH by month (all banks included)

Source: compiled based on (National Bank of Ukraine, 2024a).

Although the coefficient of variation is relatively high for both types of deposits, this study focuses not on the absolute values of the indicator (as they are largely determined by the overall state of the banking system), but rather on its dynamics. It is the changes in this indicator that allow for the assessment of the evolving riskiness of the deposit base and, indirectly, the level of depositor confidence in the banking system.

Specifics of Depositor Trust in Government-Owned Banks, Banks of Foreign Banking Groups, and Private Banks

1. Hryvnia-Denominated Bank Deposits

Throughout the study period, Ukraine's banking sector underwent significant structural transformations associated with large-scale bank insolvencies and restructuring of

banking institutions. To minimize the impact of these processes on the analysis results, the sample includes only those banks that continued operating at the end of the study period. This approach helps avoid distortions caused by license withdrawals, mergers, acquisitions, or liquidations, which would otherwise hinder a reliable assessment of deposit dynamics over the long term.

For a more in-depth analysis, banks were classified into three main groups based on ownership structure: GBs, FBs, and PBs. This classification allows for an examination of depositor behavior within each segment, taking into account trust in ownership, reputational factors, and business models.

Figure 9 presents the distribution of DDs and TDs across these groups of banks.

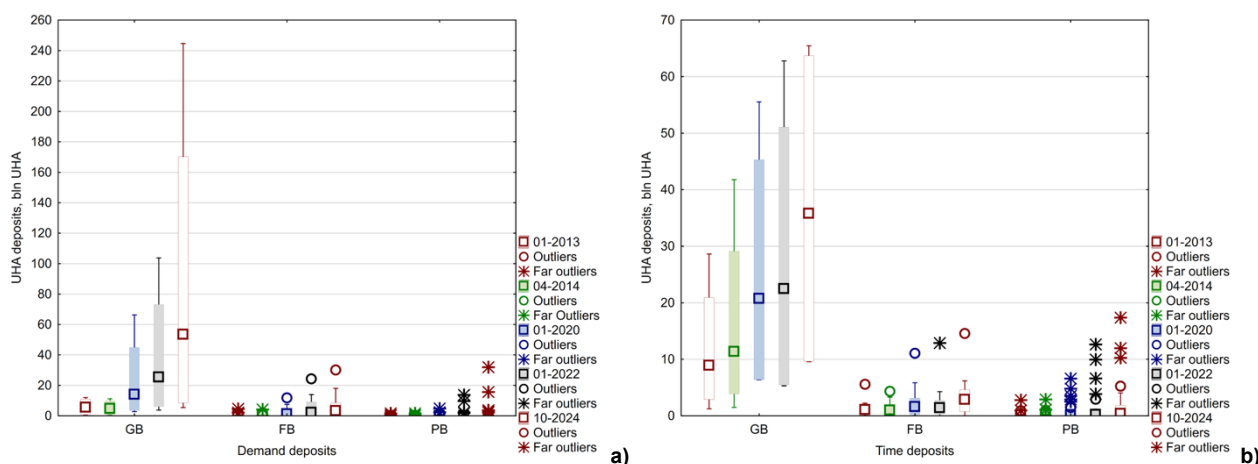


Fig. 9. Distribution of Hryvnia DDs (a) and TDs (b) by Bank Groups in January 2013, April 2014, January 2020, January 2022, and October 2024 (the sample includes only those banks that continued operating at the end of the study period)

Source: compiled based on (National Bank of Ukraine, 2024a).

Since 2020, there has been a clear shift in depositor trust in favor of GBs, driven by the perception of these institutions as more reliable. It is important to note that bank classification by ownership group was fixed as of February 1, 2022. This fixed classification allows for a consistent comparative analysis of deposit dynamics across different types of banks. FBs have shown only a modest increase in demand deposits, indicating a limited level of trust during times of crisis. PBs remain the least attractive to depositors in periods of instability, with increases in trust being rare occurrences. The results point to structural changes in depositor behavior: in the face of external shocks (particularly the full-scale invasion in 2022), individuals tend to prefer GBs as a relatively safer option for storing liquid funds.

Regarding TDs, a slight but steady increase in trust toward banks belonging to FBs is observed. At the same time, PBs show significant variability in the volumes of TDs, indicating an unusual spread – some banks accumulate substantially larger volumes of deposits compared to others. This concentration may be driven by aggressive interest rate policies, a high level of recognition of certain banks among households, or the retention of a specific segment of large depositors.

A more detailed overview of DDs and TDs in FBs and PBs is presented in Fig. 10. Despite the full-scale invasion, the interquartile range for DDs in FBs in October 2024 nearly reached the level observed before the invasion, and for TDs, it even exceeded the pre-war level, indicating partial stabilization. The increase in the median value suggests a rise in the baseline level of depositor trust. The identified outliers are isolated and do not significantly affect the overall picture.

The situation in PBs differs substantially. Compared to GBs and FBs, PBs did not show a noticeable increase in the volumes of DDs. This may be the result of a lower level of competitiveness or a focus on alternative sources of funding. The presence of far outliers indicates that some PBs are accumulating substantial volumes of funds. This situation may be explained either by a high level of public recognition of these banks or by the specific characteristics of their client base, particularly the servicing of individuals with deposits exceeding the guaranteed coverage level.

GBs account for 71% of deposits from all DDs in UAH and 56% of TDs in UAH, FBs for 16% and 17%, PBs for 13% and 28% as of October 2024. GBs demonstrate fairly stable depositor confidence, as confirmed by chain growth rates. However, the maturity structure of deposits remains a matter of serious concern, as the ratio of term deposits to demand deposits decreased by 79.4% overall (Table 2).

The dynamics of deposits in GBs demonstrate important transformations during periods of instability (Table 2). During the first phase of the war, there was a significant outflow of funds from GBs (even if we exclude Privatbank, which we included in GBs, this would only reduce the outflow of funds by 5 percentage points). In 2020, during the COVID-19 pandemic, there was a significant increase in DDs by more than 29%, while TDs grew by 4.4% in just 6 months. During the full-scale invasion between January 2022 and April 2022, DDs grew by 24.5%, while TDs fell by 7.4%.

In FBs, there was also a significant outflow of deposits during the first phase of the war. In 2020, during the COVID-19 pandemic, there was a significant increase in DDs by more

than 22%, but TDs fell by 2% in 6 months. During the full-scale invasion between April 2022 and January 2022, growth for DDs was only 16.8%, while TDs fell by 7.3%.

There is trust in FBs, but it is still not at the same as in GBs (Table 2).

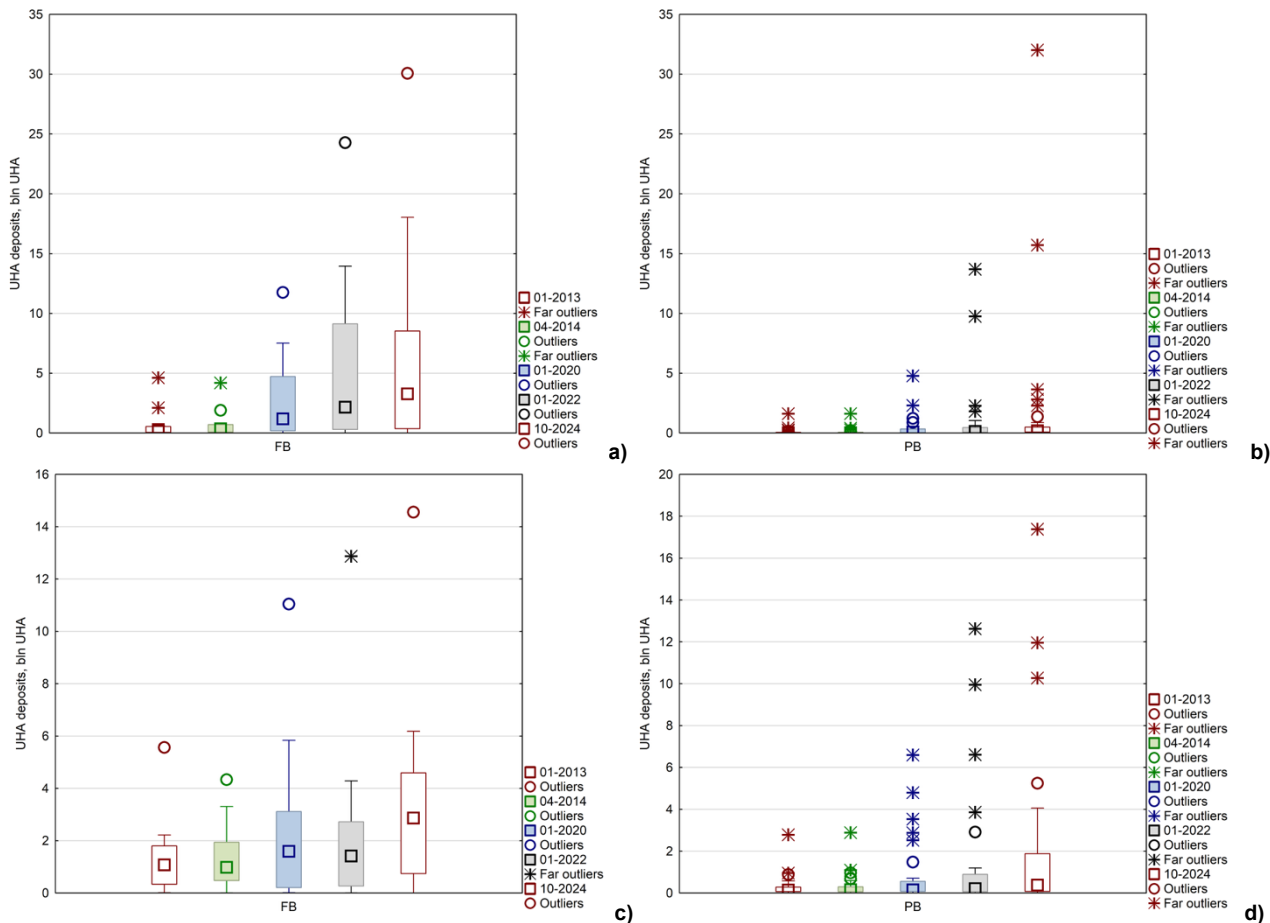


Fig. 10. Distribution of DDs in hryvnia (a, b) and TDs (c, d) in FBs (a, c) and PBs (b, d) in January 2013, April 2014, January 2020, January 2022, and October 2024 (the sample includes only those banks that continued operating at the end of the study period)

Source: compiled based on (National Bank of Ukraine, 2024a).

Table 2

Changes in hryvnia deposits in GBs, FBs, and PBs during crisis periods (the sample includes only those banks that continued operating at the end of the study period. Privatbank was included in GBs from 2013 as an assumption)

Date	GBs						FBs						PBs					
	UAH deposits, bln UAH			Chain growth rate, %			UAH deposits, bln UAH			Chain growth rate, %			UAH deposits, bln UAH			Chain growth rate, %		
	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs
01.2013	24	48	2.0	-	-	-	14	29	2.0	-	-	-	4	10	2.6	-	-	-
07.2013	29	58	2.0	21.9	21.4	-0.4	17	35	2.0	22.8	22.5	-0.2	5	11	2.1	40.7	16.1	-17.5
01.2014	28	72	2.6	-3.7	24.5	29.4	16	34	2.1	-4.1	-1.8	2.4	5	12	2.5	-10.8	4.5	17.1
04.2014	21	66	3.1	-23.7	-8.4	20.0	13	29	2.2	-20.4	-14.8	7.0	4	11	2.8	-21.1	-10.8	13.0
01.2020	97	103	1.1	352.4	56.7	-65.4	35	32	0.9	170.2	10.7	-59.0	14	28	2.0	268.5	166.3	-27.7
07.2020	126	108	0.9	29.9	4.4	-19.7	43	32	0.7	22.3	-2.0	-19.9	18	33	1.8	32.4	14.9	-13.2
01.2022	158	113	0.7	25.5	4.7	-16.6	68	31	0.5	56.6	-2.8	-38.0	35	47	1.3	90.6	45.4	-23.7
04.2022	197	105	0.5	24.5	-7.4	-25.6	79	29	0.4	16.8	-7.3	-20.7	48	43	0.9	35.7	-8.8	-32.8
07.2024	357	146	0.4	81.2	39.6	-22.9	74	44	0.6	-6.2	54.5	64.8	63	71	1.1	31.6	65.1	25.4
10.2024	357	147	0.4	0.1	0.4	0.4	79	44	0.5	6.6	-1.3	-7.4	66	72	1.1	4.6	1.5	-3.0
Total:	x	x	X	1,391.4	207.6	-79.4	x	x	X	466.2	52.6	-73.1	x	X	x	1,620.9	634.7	-57.3

Source: calculated by authors based on (National Bank of Ukraine, 2024a).

During the first phase of the war, there was also a significant outflow of funds from PBs. In 2020, during COVID-19, there was a significant increase in DDs (higher than in GBs and FBs)—by more than 30% and by more than

14% in TDs in just 6 months. During the full-scale invasion between January 2022 and April 2022, DDs grew by 35.7%, while TDs decreased by more than 8%.

Thus, we can conclude that, based on the results of the analysis of hryvnia deposits in crisis conditions, it cannot be said that there are clearly trusted banks. Of course, GBs are preferred, but the population's trust in private and foreign banks needs further study, particularly in terms of the behavior of large depositors, i.e., depositors with deposits exceeding the guaranteed amount. It is also worth noting that the ratio decline is smallest in private banks. However, this can probably be explained by an analysis of interest rates: private banks offer much higher rates on TDs than other banks.

2. Foreign Currency Denominated Bank Deposits

The distribution of foreign currency deposits across bank groups differs significantly from that of hryvnia deposits. A clear decline in interest in TDs in foreign currency is observed across all bank groups. In terms of DDs, FBs – alongside GBs – emerge as active players. PBs, as in the case of hryvnia deposits, exhibit numerous extreme outliers (see Fig. 11, Fig. 12).

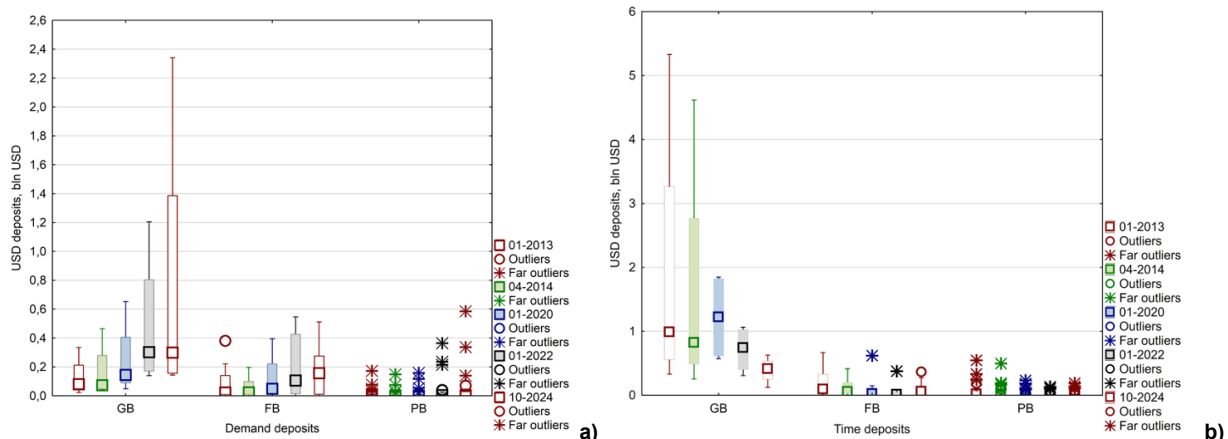


Fig. 11. Distribution of DDs (a) and TDs (b) in foreign currency by bank groups in January 2013, April 2014, January 2020, January 2022, and October 2024 (the sample includes only those banks that continued operating at the end of the study period)
Source: compiled based on (National Bank of Ukraine, 2024a).

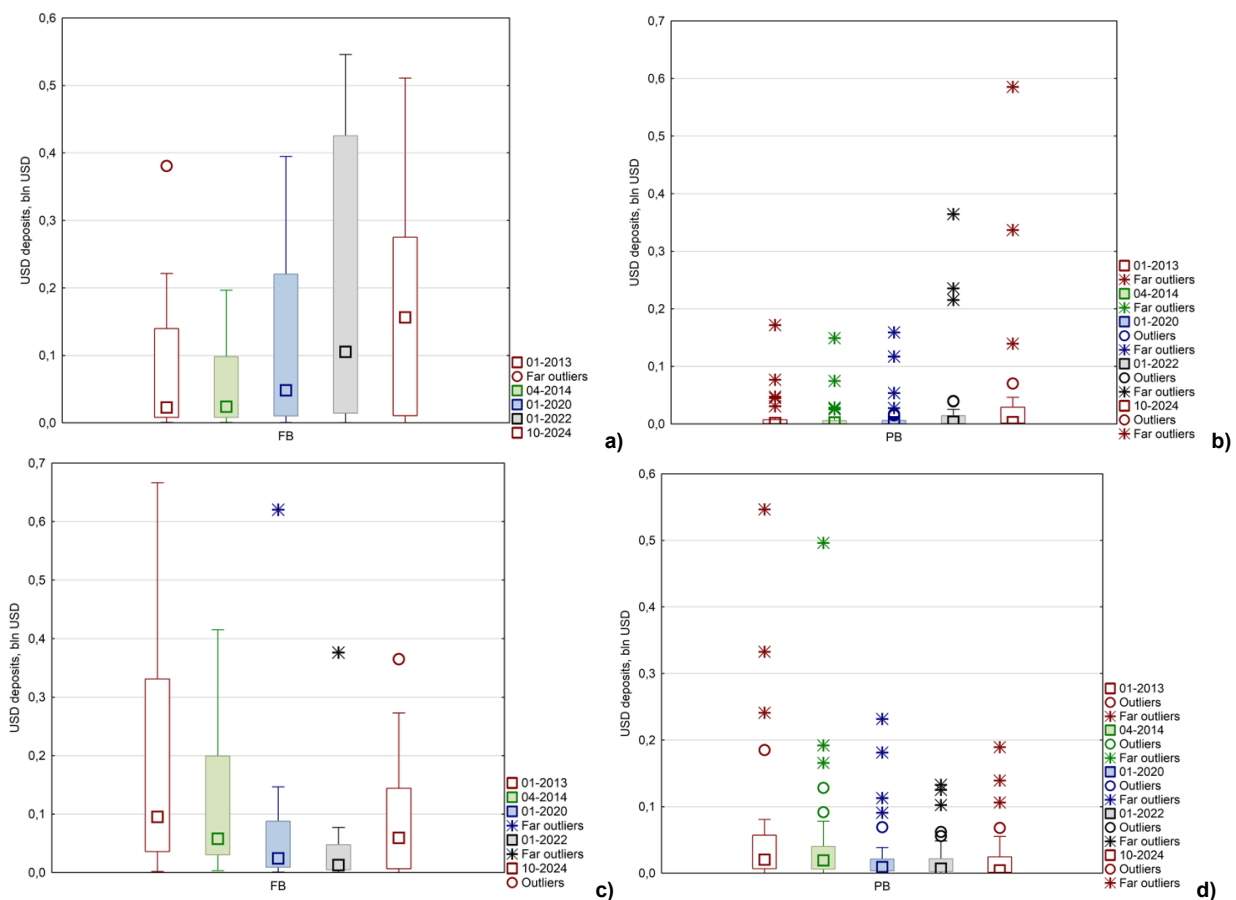


Fig. 12. Distribution of DDs (a, b) and TDs (c, d) in foreign currency in FBs (a, c) and PBs (b, d) as of January 2013, April 2014, January 2020, January 2022, and October 2024 (the sample includes only those banks that continued operating at the end of the study period)

Source: compiled based on (National Bank of Ukraine, 2024a).

As of October 2024, GBs accounted for 49% of DDs in foreign currency and 44% of TDs. FBs held 30% of DDs and 33% of TDs, while the share of PBs was 21% of DDs and 22% of TDs. This structure indicates the leading role of GBs and FBs in household foreign currency savings, with the private segment playing a relatively minor role.

GBs demonstrate growing depositor confidence in the liquid portion of savings: demand deposits increased sixfold between 2013 and 2024. Chain growth rates of DDs

remained mostly positive, especially during shocks. During the full-scale invasion, they grew by 2.6% in January–April 2022 and by another 49.3% by July 2024. However, the dynamics of DDs were completely different, falling much faster: their volumes decreased almost fivefold, and the overall reduction in the TDs/DDs ratio was over 96%. This indicates a profound transformation in foreign currency deposit behaviour toward liquidity, despite the overall level of trust in GBs (Table 3).

Table 3

Changes in foreign currency deposits in GBs, FBs, and PBs during crisis periods
(the sample includes only those banks that continued operating at the end of the study period)

Date	GBs						FBs						PBs					
	FC deposits, bln USD			Chain growth rate, %			FC deposits, bln USD			Chain growth rate, %			FC deposits, bln USD			Chain growth rate, %		
	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs	DDs	TDs	TDs/DDs
01.2013	0.5	7.6	14.7	-	-	-	1.0	2.3	2.3	-	-	-	0.4	2.1	4.7	-	-	-
07.2013	0.6	7.6	13.5	7.9	-1.1	-8.4	0.9	2.1	2.2	-6.5	-10.1	-3.9	0.5	2.1	4.1	10.5	-2.8	-12.0
01.2014	0.5	7.7	14.3	-4.6	1.4	6.3	0.8	1.9	2.4	-15.8	-9.1	8.1	0.4	2.1	5.2	-19.5	1.6	26.1
04.2014	0.7	6.5	10.0	22.5	-14.9	-30.5	0.7	1.5	2.3	-15.1	-20.4	-6.2	0.4	1.7	4.3	0.9	-17.2	-17.9
01.2020	1.0	4.9	4.9	51.4	-25.3	-50.7	1.4	1.1	0.8	105.6	-29.3	-65.6	0.5	1.0	2.2	16.2	-40.8	-49.0
07.2020	1.1	4.3	3.8	15.7	-10.9	-23.0	1.6	0.9	0.6	19.7	-13.6	-27.8	0.6	0.9	1.4	36.7	-10.2	-34.3
01.2022	1.9	2.9	1.5	70.0	-34.2	-61.3	2.4	0.6	0.3	46.3	-33.8	-54.7	1.1	0.8	0.7	68.5	-12.3	-48.0
04.2022	2.0	2.3	1.2	2.6	-18.2	-20.3	2.3	0.5	0.2	-3.4	-10.9	-7.7	1.0	0.6	0.6	-3.3	-21.7	-19.0
07.2024	3.0	1.6	0.5	49.3	-31.6	-54.2	1.8	1.2	0.6	-20.7	111.8	167.3	1.3	0.8	0.6	26.0	24.2	-1.4
10.2024	3.1	1.6	0.5	3.4	-1.1	-4.3	1.9	1.2	0.6	2.5	1.1	-1.4	1.3	0.8	0.6	-0.4	1.7	2.0
Total:	x	x	x	494.1	-79.3	-96.5	x	x	x	88.7	-49.8	-73.4	x	x	x	191.7	-62.3	-87.1

Source: calculated by authors based on (National Bank of Ukraine, 2024a).

The reaction for FBs was somewhat different. Although the total volume of DDs in foreign currency grew (+88.7% over the entire period), TDs decreased by almost 50%. However, the overall reduction in TDs/DDs ratio by 73% indicates a similar trend of TDs reduction as in other groups.

Foreign currency deposits have always accounted for a small share of private banks' total deposits. Nevertheless, during the COVID crisis, DDs grew by 36.7%, while TDs fell by more than 10%. The overall reduction in the TDs/DDs ratio was over 87%, reflecting the limited willingness of the population to trust PBs in the foreign currency segment, especially for the long-term.

Overall, all three groups of banks showed a clear structural change in their foreign currency deposit portfolios: DDs dominated amid a decline in TDs, with some differences in the scale and speed of change. The highest liquidity was in the public sector, while the sharpest volatility was in FBs and PBs.

Discussion and conclusions

The study demonstrated that the effectiveness of the deposit guarantee system in Ukraine is shaped both by explicit instruments (the DGF) and implicit support from the state, especially during crises. This implicit component has a significant impact on depositors' behaviour and has proved crucial during periods of deep instability (war and pandemic).

During periods of crisis, structural changes in household deposits were observed. First, the shift from time deposits to demand deposits is evidence of short-term confidence in the banking sector. Only in isolated cases, particularly in 2020, was there an overall increase in deposits, primarily in government-owned banks, which again underscores the importance of implicit support. The DGF fulfils its role under stable macroeconomic conditions. However, its effectiveness is significantly reduced during shock events. As the analysis has shown, despite the formal existence of a protection mechanism, depositors' behaviour is

determined not only by the size of the guaranteed amount, but also by expectations of government support for banks.

Second, government-owned banks in Ukraine play a dominant role, accounting for the bulk of hryvnia deposits. In times of crisis, they tend to have the highest level of public confidence. Foreign banks occupy a stable but less significant position: they are perceived as reliable but less attractive for term deposits. Private banks demonstrate the highest volatility of the deposit base, which requires further research.

Thus, the explicit deposit guarantee system in Ukraine performs a basic stabilising function under normal conditions. At the same time, during crises, the implicit deposit guarantee system is decisive. This points to the need to rethink the role of the explicit deposit insurance system and strengthen it through institutional reforms, expanding protection tools, and increasing adaptability to shocks.

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ДЕПОЗИТИ ДОМОГОСПОДАРСТВ І СХЕМИ ЇХНЬОГО ГАРАНТУВАННЯ У КРИЗОВІ ПЕРІОДИ В УКРАЇНІ

Вступ. Забезпечення стабільності банківської системи залишається ключовим викликом під час економічних і геополітичних криз. В Україні система гарантування вкладів містить як явні (експліцитні), так і неявні (імпліцитні) компоненти. Явний механізм представлений Фондом гарантування вкладів фізичних осіб (ФГВФО), неявний компонент відображає суспільну довіру до ролі держави у захисті вкладів, особливо в умовах форс-мажорних обставин. Це дослідження має на меті оцінити стабільність вкладів у банках України під час кризових періодів.

Методи. У дослідженні застосовано описовий статистичний аналіз динаміки вкладів із розподілом за формою власності банків (державні, іноземні, приватні) та валютою вкладу (національна й іноземна) у період з 2013 по 2024 рр. Аналіз охоплює показники ланцюгових темпів зростання та структури депозитів (депозити на вимогу та строкові вклади) у ключові фази криз: воєнна агресія 2014 р., пандемія COVID-19 і повномасштабне вторгнення 2022 р.

Результати. Отримані результати свідчать про те, що імпліцитна система гарантування відіграла ключову роль під час значних шоків, причому державні банки демонстрували вищу стабільність вкладів. Структура депозитів суттєво зміщувалася в бік депозитів на вимогу, особливо у періоди невизначеності. Спостерігалися суттєві відмінності залежно від форми власності: іноземні банки демонстрували помірний рівень довіри, тоді як у приватних банках спостерігалися значні коливання обсягів вкладів. Валютна специфіка підкреслила важливість аналізу вкладів як у гривні, так і в іноземній валюті з огляду на вплив девальвації та інфляційних очікувань.

Висновки. Комплексне розуміння поведінки вкладників в умовах стресу вимагає оцінювання як експліцитного, так і імпліцитного захисту. Попри те, що ФГВФО забезпечує надійну основу, його ефективність має підкріплюватися дієвими неявними гарантіями та системами антикризового управління. Девальвація валюти та структура власності банків є критичними факторами у визначенні стійкості депозитної системи.

Ключові слова: система гарантування вкладів, експліцитна система гарантування вкладів, імпліцитна система гарантування вкладів, фінансова криза, стійкість банківської системи.

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RISK ANALYSIS IN THE SYSTEM OF OTHER (NON-PRICE) METHODS FOR EVALUATING TENDER PROPOSALS

Background. *Non-price criteria are an important strategic tool for achieving social, environmental, and economic objectives. However, their practical application may be accompanied by a number of problems and risks. This study aims to identify the main problems and risks associated with the use of non-price evaluation criteria and to develop well-grounded recommendations in the context of establishing effective safeguards to neutralize or mitigate these risks.*

Methods. *The study employed the special legal method for analyzing the regulatory framework, case analysis to examine specific procurement examples, the statistical method for processing empirical data, as well as a systems approach to generalize findings and formulate reasoned proposals.*

Results. *An analysis was conducted of the regulatory framework, statistical data, and individual practical cases related to the use of non-price criteria in evaluating tender proposals in Ukraine and EU member states. The research showed that, despite the formal recognition of the advantages of this tool, its practical application remains limited due to legal uncertainty, low awareness among contracting authorities, and the risk of abuse. Even the positive experience of European countries demonstrates that the active use of non-price criteria does not always guarantee successful outcomes and, in some cases, leads to distorted bidding results. At the same time, under conditions of proper regulation and effective procurement oversight, non-price criteria can become a powerful tool for shaping a transparent, results-oriented, and socially responsible procurement system.*

Conclusions. *Public procurement practice in Ukraine demonstrates a low level of application of non-price evaluation criteria, which is driven by legal ambiguity and the risk of abuse. To improve the situation and encourage more frequent use of non-price criteria by contracting authorities, it is essential not only to adopt European approaches but also to ensure appropriate conditions for their implementation through comprehensive reforms.*

Keywords: *public procurement, evaluation of tender proposals, non-price criteria, life-cycle cost, risks, Prozorro, competitiveness, European integration.*

Background

Ukraine's association with the European Union seeks the rapid alignment of national legislation with EU standards across all socio-economic spheres. In this context, the harmonization of legal regulation in the public procurement system is considered one of the priority tasks on the path to European integration, as it is part of the first negotiation cluster, "Fundamentals of the accession process to the European Union".

According to the provisions of the Association Agreement, Ukraine has committed to aligning its procurement policy with the standards of the European Union, which place considerable emphasis on the use of non-price criteria for evaluating tender proposals. These criteria shift the focus beyond price, enabling the selection of the most economically advantageous offer by also considering quality, innovation, environmental impact, social responsibility, and other factors. This approach delivers long-term value for money and supports the state's sustainable development.

However, the introduction of non-price criteria is not without risks. On one hand, it requires complex formulation and justification of criteria; on the other, it demands high qualifications from procurement participants. There is a risk of abuse in setting specific criteria and complications in challenging procurement decisions. Therefore, it is critically important for Ukraine not only to formally implement

European approaches but also to build institutional capacity for their effective application. This requires clearly defining the procedures and methods of applying non-price evaluation criteria in legislation, training procurement personnel, and increasing transparency at all stages of the procurement process.

The aim of the work is to identify the key problems and risks associated with the use of non-price criteria for evaluating tender proposals in the public procurement system and to formulate reasoned recommendations to neutralize potential threats and minimize their impact on procurement outcomes.

Literature review. The European development vector is defined as a strategic priority of Ukrainian statehood, opening broad opportunities for the country's socio-economic growth and contributing to increased living standards. The signing of the Association Agreement between Ukraine and the European Union marked the beginning of a new stage of bilateral cooperation and demonstrated Ukraine's readiness for radical reforms, primarily requiring the modernization of the national legal framework and its alignment with EU standards. Issues related to the adaptation of Ukraine's economy to EU standards were studied in the works of Novikova (2016), Mytsiuk and Mehey (2018). In particular, the harmonization of EU legislation in the field of public procurement with Ukrainian legislation was addressed in the study by Roshyan (2023).

Public procurement plays a special role in the system of economic governance, as a significant portion of budgetary resources is reallocated through procurement annually. In EU countries, public procurement accounts for 14% of GDP, amounting to 2 trillion euros, making it one of the main drivers of employment and economic growth in the European Union (European Court of Auditors, 2023). This underscores the need for adequate control and risk management in the public procurement system.

In this context, particular academic value lies in publications from the *Journal of Public Procurement* – a leading international peer-reviewed journal indexed in Scopus, which specializes in public procurement research. In particular, Paraskeva and Tsoulfas (2025), in their article, explore the key challenges and risks arising at various stages of procurement and propose ways to minimize them. They highlight the need for greater transparency, digital innovation, and higher professional standards among procurement personnel. The authors stress that strengthening these aspects is critical for reducing vulnerabilities – especially in the context of combating corruption risks, which remain among the most pressing challenges in public procurement. Corruption risks and their consequences in public procurement were analyzed by Gnoffo (2021), while Heikkinen and Halonen (2025) highlighted the importance of trust in the procurement process and in the judicial review system. Lack of trust negatively affects the willingness of businesses to participate in tenders, undermining competition, the efficient use of public funds, and the achievement of broader goals such as sustainable development.

An important tool for the efficient use of public funds is the application of non-price criteria in the evaluation of tender proposals. In particular, Baranovsky et al. (2020) devote significant attention to the implementation of the "value for money" principle, which consists in achieving maximum benefit from the available funds by assessing not only the price criterion but also the long-term efficiency of procurement. A similar approach is supported by Karlin (Karlin, 2021), who notes that the use of a multi-criteria evaluation system helps better account for the qualitative characteristics of proposals and reduces the risks of concluding contracts with unscrupulous suppliers.

This issue is of particular importance in the construction sector, which is characterized by complex working conditions, high competition, heavy workloads, and numerous challenges during project implementation. An unsuccessful choice of contractor can lead to delays, cost overruns, a decline in work quality, disputes, and additional expenses for the client. In his study, Oz (2024) analyzes this problem in detail and proposes an innovative model for evaluating tender proposals that allows for achieving an optimal balance between price and quality, reducing the likelihood of engaging unreliable contractors, and increasing the chances of successful project implementation in the challenging conditions of the construction industry.

However, achieving the optimal balance between price and quality is only one of the advantages that can be realized through the use of non-price criteria in tender evaluation. Another advantage is that such criteria help achieve broader social goals, such as fostering innovation, promoting environmental initiatives, and strengthening social responsibility – a point stressed by Brzeziński (2024). The implementation of such goals not only increases social welfare but also helps form a positive image of the authorities and demonstrates to voters their willingness to act in the public interest. This, in turn, builds political support

for using non-price criteria, as noted by Lerusse and Van de Walle (2022).

In Ukraine, unfortunately, despite the legal right to apply non-price evaluation criteria, their use in practice remains less common than in European countries. At the same time, the results of individual studies indicate significant potential for their use in addressing urgent social issues. In particular, in the context of environmental degradation, the implementation of protective measures is becoming increasingly relevant. This issue was addressed by Kharchenko et al. (2023), who analyzed the specifics of applying non-price criteria to implement environmental protection measures in the road sector and proposed integrating the European Union's "Green Public Procurement" criteria into the design, construction, and maintenance of roads.

Thus, the review of the cited literature makes it possible to outline the key advantages of applying non-price evaluation criteria. At the same time, along with studying the positive aspects, the effective use of such criteria requires a thorough analysis of the existing challenges, which, in turn, necessitates further research aimed at identifying risks and developing effective mechanisms for their mitigation.

Methods

To achieve the stated goal, the article applies a set of interrelated research methods that ensure a systemic analysis of issues related to the application of non-price criteria in public procurement. The special legal method was used to analyze Ukrainian and EU legal acts, including Directive 2014/24/EU, the Law of Ukraine "On Public Procurement", and the Association Agreement. Case analysis was used to examine specific procurement cases and identify common violations and deficiencies in the practical application of non-price criteria. The statistical method processed data obtained from the BI Prozorro analytics module and the European Court of Auditors report, enabling the identification of quantitative indicators and trends. A systems approach was used to synthesize findings and develop practical recommendations for improving the application of non-price evaluation mechanisms.

Results

The Association Agreement between Ukraine and the European Union includes Ukraine's obligation to gradually adapt its procurement legislation to EU norms and standards. Under this agreement, Ukraine must ensure a transparent, competitive, and non-discriminatory procurement system based on principles that guide procurement in EU countries (Verkhovna Rada of Ukraine, 2014).

Currently, the main legal act regulating public procurement at the EU level is Directive 2014/24/EU (European Parliament & Council of the European Union, 2014). It sets general procurement rules and emphasizes the efficient and rational use of funds. Article 67 of this directive states that contracts must be awarded based on the most economically advantageous tender (European Parliament and Council of the European Union, 2014). This refers not only to price but to all qualitative and technical characteristics that best meet the purchaser's needs. EU law provides two additional evaluation methods besides the traditional price-based approach: life-cycle costing (LCC) and the price-quality ratio.

Life-cycle costing accounts not only for the purchase price of goods, works, or services but also for all related costs from acquisition to disposal. These may include transportation, installation, operation (e.g., energy consumption, maintenance), and disposal (e.g., waste treatment) costs. Considering future expenses enables

contracting authorities to evaluate economic viability more objectively and make procurement decisions with long-term benefits in mind. However, implementing this method requires in-depth analysis and may involve risks.

LCC-based procurement is typically used when a long-term use of the procured item is expected. This requires suppliers to take on extended obligations, with the risk that they may fail to fulfill them. This justifies setting additional qualification requirements for bidders, such as financial stability and experience. It is advisable to include contractual guarantees to ensure performance throughout the life cycle of the item. The contract should clearly define the scope, frequency, and nature of services, and provide a mechanism for transferring obligations if the original supplier ceases operations. Compensation terms should also be outlined if the buyer does not agree to supplier replacement.

An alternative approach is evaluating tenders based on the price-quality ratio as set out in Directive 2014/24/EU. Evaluation criteria may include product quality, design,

innovation, environmental or social characteristics, and staff qualifications. The buyer can select multiple relevant indicators, assign a weight to each, and calculate a weighted score to assess offers comprehensively. However, excessive discretion in defining non-price criteria can create corruption risks. It allows for arbitrary exclusion of bidders based on vague or narrowly tailored criteria, undermining fair competition and transparency. In such cases, procurement may serve pre-selected contractors, violating the principles of equality and non-discrimination.

According to the European Court of Auditors Report No. 28/2023, the share of procurement procedures in the internal market of the European Union with only one bidder increased from 23.5% to 41.8% during the period 2011-2021 (European Court of Auditors, 2023). A level above 20% is considered high in the European Union; therefore, the figure rose from high in 2011 to even higher in 2021. The highest rates were recorded in Slovenia, Cyprus, Poland, the Czech Republic, and Hungary (see Fig. 1).

Competition Indicator Trends 2011 - 2021: Single bidding (%)



Fig. 1. Share of procurement procedures in the internal market of the European Union with only one bidder in 2011–2021
Source: Special Report 28/2023 (European Court of Auditors, 2023).

An analysis was also conducted across specific economic sectors: construction, energy, engineering, financial services, health services, medical equipment, repairs, sewage services, transport equipment, and transport services. All of these sectors demonstrated a

significant increase in the number of tenders with only one bidder. The highest level of single-bid participation - with a continuing upward trend – was recorded in tenders related to repair works, where the share increased from 22% in 2011 to 47% in 2021 (see Fig. 2).

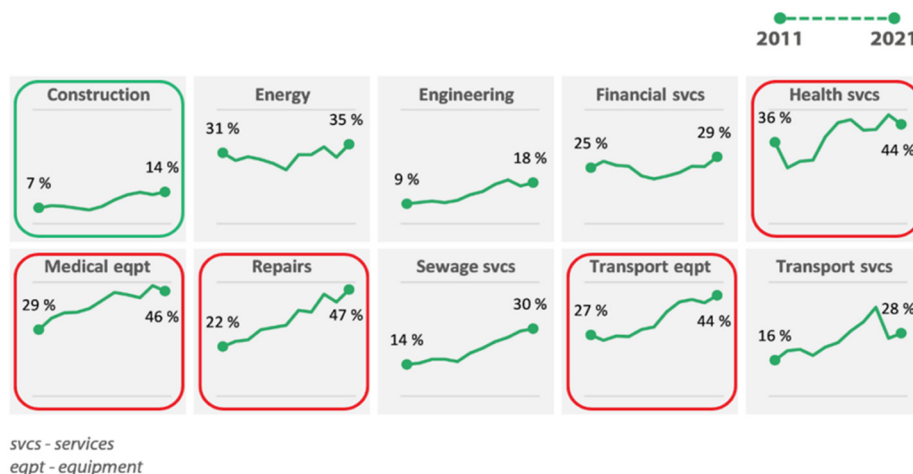


Fig. 2. Share of procurement procedures in the internal market of the European Union with only one bidder by sector in 2011–2021
Source: Special Report 28/2023 (European Court of Auditors, 2023).

According to information published on the official website of the European Commission, the situation regarding the share of tenders with only one bidder worsened further in 2023. Within the European Union, a satisfactory level is considered to be no more than 10% of such procedures out of the total number of procurements conducted; an average level is up to 20%, while exceeding

this threshold indicates an unsatisfactory state of market competition. In previous years, at least 3-4 EU Member States showed acceptable figures, but by the end of 2023, not a single country met the "satisfactory" criterion. In Figure 3, the bars represent the share of procurement procedures with only one bidder in various EU countries in 2023, identified by their ISO country codes.

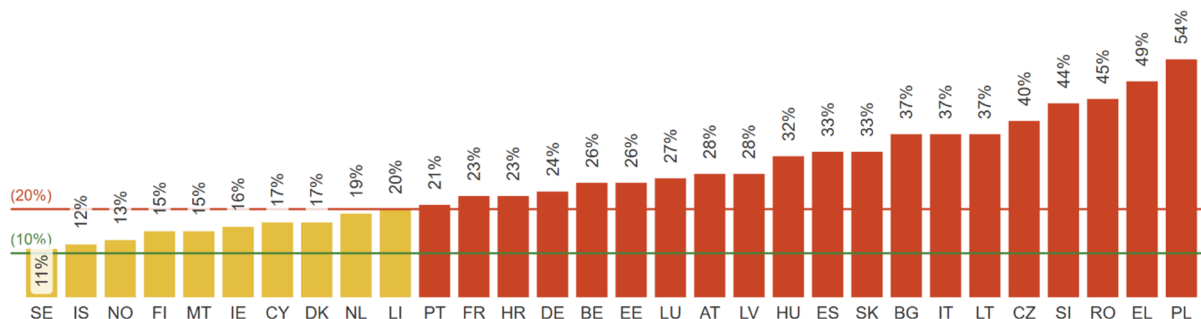


Fig. 3. Share of procurement procedures in the internal market of the European Union with only one bidder in 2023

Source: access to public procurement (European Commission, 2025).

The main reason for the low level of competition in public procurement, according to respondents, is the "restrictive requirements" set by contracting authorities. According to a study commissioned by the European Commission, it was found that 18% of procurement-related expenditures are losses caused by inefficiency, of which 13% are directly linked to corruption. One of the most common forms of corruption contributing to this inefficiency is collusion between the contracting authority and the supplier (UNESCO IIEP, 2021).

In Ukraine, the concept of non-price criteria in procurement is also not a new phenomenon, although the mechanism for their application is still undergoing reform in accordance with best practices of European Union Member States. The use of non-price criteria for evaluating tender proposals was already provided for in the laws regulating the procurement sector since the 2000s. In particular, such provisions were included in the Law of Ukraine "On the Procurement of Goods, Works and Services at the Expense of State Funds" dated 22 February 2000, the Law of Ukraine "On Public Procurement" dated 1 June 2010, and the Law of Ukraine "On Public Procurement" dated 10 April 2014. At present, the main legislative act governing this issue is the Law of Ukraine "On Public Procurement" dated 25 December 2015.

In the version of the Law of Ukraine "On Public Procurement" in force until April 19, 2020, the use of non-price criteria for evaluating tender proposals was significantly limited and allowed only in cases of complex or specialized procurements. This applied, in particular, to the procurement of consulting services, scientific research, experimental, or R&D work. The new version of the Law of Ukraine "On Public Procurement" greatly expanded the rights of contracting authorities to set additional evaluation criteria, allowing their use in any procurement procedure without mandatory justification. This liberalization, on the one hand, granted contracting authorities greater flexibility in considering the qualitative characteristics of the procurement item, but on the other hand, it led to the emergence of new corruption risks related to the potential for biased formulation of criteria to favor a specific supplier, and distortion of competition.

One illustrative example is the case involving the procurement of surgical inpatient services by a city clinical hospital (CPV code 021:2015: 85110000-3 – "Hospital and

related services"). The contracting authority initiated an open tender procedure using non-price criteria to assess the ability to provide services to overweight patients. Specifically, 30% was assigned for the ability to serve patients weighing over 240 kg, 15% – over 230 kg, and 10% – over 210 kg (Transparency International, 2021).

These requirements were challenged before the permanent administrative board of the Antimonopoly Committee of Ukraine. The complainant referred to statistical data indicating that patients weighing more than 240 kg constitute only about 1% of all patients, suggesting the criterion was unjustified. It was also noted that only one supplier on the market had the technical capacity to meet this requirement, effectively restricting competition. The board of the Antimonopoly Committee of Ukraine upheld the complaint and ordered the contracting authority to amend the tender documentation to eliminate the discriminatory provisions.

A somewhat similar case occurred in a procurement conducted by the municipal enterprise "Odesa CHP No. 2" for the supply of salt (CPV code 021:2015: 14400000-5 – Salt and pure sodium chloride). As an additional non-price criterion, the contracting authority specified that the "distance of the participant from the contracting authority's location must not exceed 50 km," giving this criterion the maximum allowable weight of 30% (Prozorro, 2022). However, it is difficult to determine exactly what benefit the contracting authority would have gained from including this criterion, since the tender documentation stipulated that the goods were to be delivered directly to the customer's address, and delivery costs were to be included in the total price. Under these conditions, the supplier's location had no objective impact on the effectiveness of contract performance, and thus the criterion did not improve the quality of procurement or bring any added value to the buyer. In this context, the debate arises whether the contracting authority intentionally formulated the requirement to artificially narrow competition in favor of a predetermined supplier, or whether the issue lies in a lack of understanding of the essence of non-price criteria and the rules for their proper use. When non-price criteria include only one option, a bidder is forced either to agree to that one option or be excluded from participation by the system, which contradicts the very concept of non-price criteria, which are intended to increase or decrease the

competitiveness of offers, but not to prevent participation in procurement altogether.

Overall, difficulties in understanding and practically applying non-price evaluation criteria remain common among contracting authorities in Ukraine. This is a key reason for the dominance of the traditional price-based approach to evaluating tender proposals. Statistical data from the BI Prozorro analytics module confirm this trend. In

particular, between 2016 and 2025, more than 2 million competitive procurement procedures were conducted, including open tenders, open tenders with specific features, and open tenders published in English (see Fig. 4). At the same time, only a small share (slightly more than half a percent) involved the use of non-price evaluation criteria (see Fig. 5).

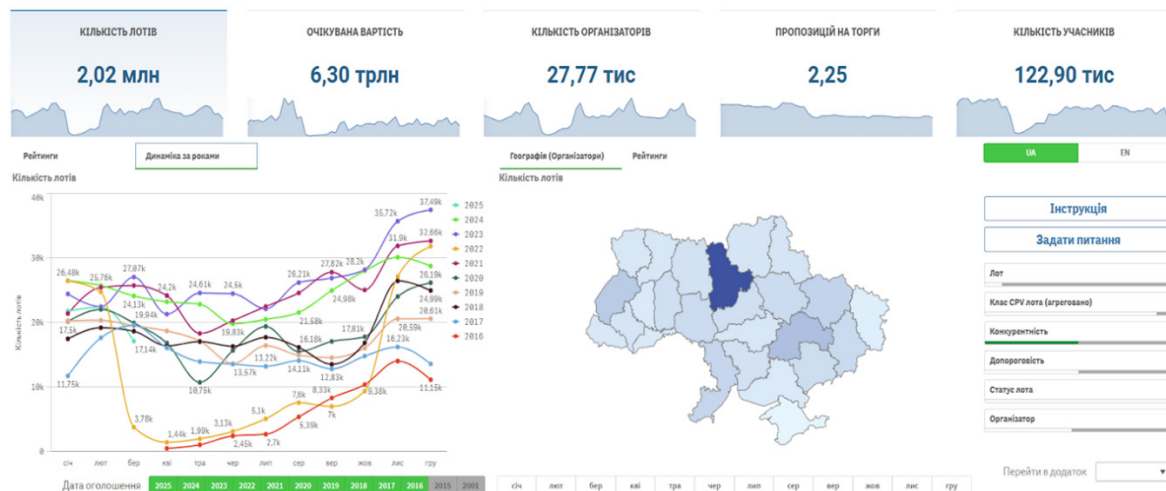


Fig. 4. Number of competitive procurement procedures in Ukraine in 2016–2025

Source: access to public procurement data (BI Prozorro Analytics Module, 2025).

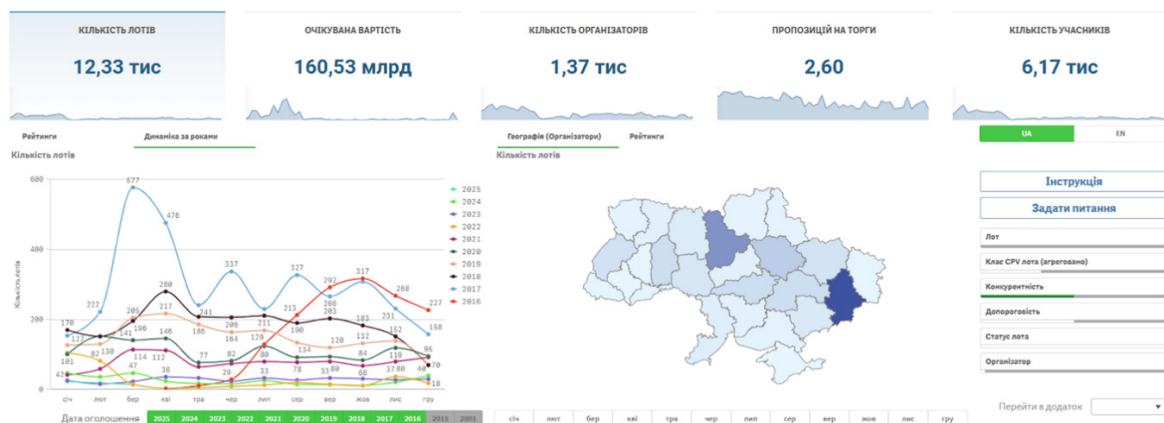


Fig. 5. Number of competitive procurement procedures in Ukraine in 2016–2025 using non-price evaluation criteria

Source: access to public procurement data (BI Prozorro Analytics Module, 2025).

Domestic contracting authorities often avoid using non-price criteria due to uncertainty about how to verify a participant's compliance. In some cases, this even leads contracting authorities to invent and include non-existent rules. For example, one of the grounds for rejection may be the reasoning that there is a "mismatch between the specific weight selected by the participant under the criterion "Total unit price value" and the format of the "Tender Proposal" submitted by the participant according to Annex No. 9 to the tender documentation" (Akademiia Radnyk, 2023).

Another issue faced by contracting authorities in applying non-price evaluation criteria in public procurement is the lack of understanding of which criteria they are allowed to select. For instance, Article 29 of the Law of Ukraine provides a specific list of non-price evaluation criteria, namely: payment terms, completion time, warranty service, technology transfer and training of managerial, scientific, and production personnel, as well as implementation of

environmental protection and/or social protection measures related to the subject of procurement (Verkhovna Rada of Ukraine, 2015). At the same time, the Ministry of Economy of Ukraine, in letter No. 3304-04/20327-06 dated April 2, 2021, clarified that this list is not exhaustive. However, the Antimonopoly Committee of Ukraine's board has already issued at least five decisions in which it effectively stated that contracting authorities may apply only those non-price criteria defined by the law.

These risks can be minimized by improving legislative regulation. The Law of Ukraine "On Public Procurement" should include a requirement for the contracting authority to justify the reason for applying each selected non-price criterion and specify whether the list of non-price criteria provided in Article 29 is exhaustive. This would help avoid an ambiguous interpretation of the law and reduce the risk of biased criteria designed to favor specific suppliers. In addition, it is necessary to regulate the procedure for verifying tender

proposals against selected criteria and introduce mechanisms for monitoring the integrity of contracting authorities by incorporating the relevant provisions either into existing legislation or through separate subordinate acts.

Another important step is to introduce systematic monitoring of procurements conducted using non-price evaluation criteria, with public reporting on common errors, violations, and best practices. Furthermore, in order to enhance the professional awareness of procurement participants, it is necessary to develop specialized training programs to ensure proper understanding of the essence of non-price evaluation criteria and the specifics of their practical application.

Discussion and conclusions

The results of the conducted study indicate that although non-price criteria for evaluating tender proposals are officially recognized as a tool for ensuring more efficient use of public funds, in practice, their application in Ukraine remains extremely limited. The main restraining factors are legal uncertainty, a low level of awareness among procurement participants regarding the application of non-price evaluation criteria, as well as the risks of abuse and distortion of competition. In such conditions, it is crucial to move from merely declaring the advantages of non-price criteria to creating real conditions for their effective and fair use.

Thus, it is critically important for Ukraine not only to formally implement European approaches but also to build institutional capacity for their proper application. This must be based on a combination of clear legislation, professional competence of procurement participants, and transparency and oversight at all stages of the procurement process. Only under such conditions can non-price criteria transform from a source of potential threats and risks into an effective tool for improving the quality of procurement.

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АНАЛІЗ РИЗИКІВ У СИСТЕМІ ІНШИХ (НЕЦІНОВИХ) МЕТОДІВ ОЦІНЮВАННЯ ТЕНДЕРНИХ ПРОПОЗИЦІЙ

В с т у п . Нецінові критерії є важливим стратегічним інструментом для досягнення соціальних, екологічних та економічних цілей, проте їхнє практичне застосування може супроводжуватися низкою проблем і ризиків. Метою дослідження є ідентифікація основних проблем і ризиків, пов'язаних із використанням нецінових критеріїв оцінювання, а також формування обґрунтованих рекомендацій у контексті формування ефективних запобіжних заходів для нейтралізації ризиків або зниження їхнього впливу.

М е т о д и . У процесі дослідження застосовано спеціально-юридичний метод для аналізу нормативно-правової бази, кейс-аналіз для аналізу конкретних закупівель, статистичний метод для опрацювання емпіричних даних, а також системний підхід для узагальнення результатів і формулювання обґрунтованих пропозицій.

Р е з у л ь т а т и . Проведено аналіз нормативно-правової бази, статистичних даних та окремих практичних кейсів щодо застосування нецінових критеріїв оцінювання тендерних пропозицій в Україні та країнах – членах Європейського Союзу. Дослідження показало, що попри формальне визнання переваг зазначеного інструменту, його практичне використання залишається обмеженим через правову невизначеність, низький рівень обізнаності замовників і ризики зловживань. Навіть позитивний досвід європейських країн демонструє, що активне використання нецінових критеріїв оцінювання не завжди гарантує досягнення успішних результатів, в окремих випадках навпаки призводить до спотворення результатів торгів. Водночас за умов належного регулювання й ефективного контролю процесу закупівель, нецінові критерії здатні стати потужним інструментом формування прозорої, результативної та соціально орієнтованої системи закупівель.

В и с н о в к и . Практика публічних закупівель в Україні свідчить про низький рівень використання нецінових критеріїв оцінювання, що зумовлено правовою невизначеністю та ризиками зловживань. Для покращення ситуації та стимулювання замовників до частішого застосування нецінових критеріїв оцінювання важливо не лише адаптувати європейські підходи, а й забезпечити належні умови для їхнього застосування за допомогою впровадження комплексних реформ.

К л ю ч о в і с л о в а : публічні закупівлі, оцінювання тендерних пропозицій, нецінові критерії, вартість життєвого циклу, ризики, Prozigro, конкурентність, євроінтеграція.

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CONSUMER BEHAVIOUR MODEL FOR ORGANIC PRODUCTS: AN EMPIRICAL STUDY OF THE UK MARKET

Background. *The growing global demand for organic products is driven by the intensification of environmental problems and a shift in consumer priorities toward safe and sustainable goods. The organic products market is shaped by a combination of economic, social, and cultural factors, which calls for a detailed examination of consumer behavior models in international markets. The purpose of this study is to enhance theoretical approaches and develop practical recommendations for applying consumer behavior models as a basis for effective strategies for businesses operating in international organic markets, thereby promoting the sustainable development of Ukraine's economy. The object of the study is the economic relations between producers and consumers in international organic markets, while the subject of the study is the theoretical and methodological aspects of forming consumer behavior models in these markets.*

Methods. *The research is based on the comprehensive application of general scientific methods (analysis and synthesis, induction and deduction, analogy and comparison, classification, systematization, quantitative and statistical analysis, etc.) and specific scientific methods (hypothetical, theoretical modeling, and visual-graphical methods). This approach made it possible to combine theoretical analysis with empirical observations to achieve the research objectives.*

Results. *It was found that none of the analyzed consumer behavior models in the domestic or international economic literature fully captures all aspects of the behavior of organic product consumers. Therefore, a comprehensive model was developed that integrates cognitive, emotional, and value dimensions in shaping consumer intention and translating it into behavior. This model served as the foundation for developing a strategy to promote the company "Danube Agrarian" in the UK market. In addition, the study identified positive social and environmental effects of the organic sector's development on Ukraine's economy.*

Conclusions. *The proposed model serves as a tool for predicting consumer behavior and can be used as a basis for developing strategies to promote products in international markets. The results obtained have practical significance for Ukrainian producers of organic products and will contribute to enhancing Ukraine's competitiveness in the global market and advancing its transition toward a sustainable development model.*

Keywords: *organic products, sustainable development, consumer behaviour, consumer behaviour models, STABS methodology, business culture models, promotion, agile contingency decisions.*

Background

The world economy has undergone significant transformations in recent decades, driven by globalization and fragmentation, rapid digitalization and the advancement of artificial intelligence technologies, the evolution of consumer values, and increasing attention to sustainable development issues. One of the most striking manifestations of these changes is the rapid expansion of the organic market, which is projected to grow by more than 288% between 2024 and 2034. The organic sector has become not only a consumer trend but also a response to the challenges posed by the environmental crisis, climate change, and declining trust in mass food production methods that rely heavily on chemical pesticides and preservatives.

The organic fruit preservation segment is particularly dynamic. On the one hand, it attracts consumers concerned about health and the environment; on the other, it creates new opportunities for producers and processors aiming to enter premium market segments. However, behind the quantitative growth of the market lies a far more complex qualitative transformation in consumer behavior. Consumer motivations are no longer limited to rational considerations such as price or quality; instead, they increasingly reflect deeper value-based beliefs, social responsibility, identity

expression, and even emotional self-realization through consumption.

The organic sector in Ukraine has significant potential for development. Currently, certified organic land in Ukraine covers about 420,000 hectares. In line with Ukraine's European integration aspirations, national legislation on organic production is expected to be harmonized with EU regulations. This creates unique opportunities for Ukrainian producers to enter international markets – particularly the UK, where, despite Brexit, there remains high demand for organic products and a strong consumer preference for environmentally responsible consumption. At the same time, this market is characterized by strict quality standards, specific consumer preferences, and intense competition, which underscores the importance of understanding cultural differences and consumer behavioral patterns.

The scientific novelty of this study lies in the development of a comprehensive model of consumer behavior for organic products. Such a model takes into account not only cognitive and social factors influencing intention formation but also the deeper value-based motivations of consumers, as well as the mechanisms that shape actual decision-making at the point of choice.

The purpose of the study is to enhance theoretical approaches and develop practical recommendations for

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applying consumer behavior models as a foundation for effective strategies in international organic product markets. In doing so, it seeks to contribute to the sustainable development of the Ukrainian economy. The object of the study is the economic relationships between producers and consumers in international organic product markets. The subject of the study is the theoretical and methodological aspects of forming consumer behavior models within these markets.

The **objectives** of the study are to: develop a comprehensive model of consumer behavior for organic products; determine the impact of business environment factors on the activities of organic fruit preserve producers in the Danish and UK markets; propose a consumer behavior model specifically for the UK organic fruit preserve market; develop strategic recommendations for promoting organic fruit preserves in the UK market; and identify the environmental and social effects of the production and consumption of organic products on the Ukrainian economy.

Literature review. Scientific interest in studying the behavioral patterns of organic product consumers is considerable. The theoretical foundations for the study of consumer behavior were laid by scholars such as D. Aaker, T. Veblen, W. Sombart, R. Cardozo, W. Kohler, F. Kotler, R. Lowe, A. Marshall, and S. Freud. Among modern Ukrainian researchers, the works of L. O. Vasylykevych, T. Zhovkovska, V. V. Zhurylo, and O. Yu. Pryhara are particularly noteworthy, as they examine consumer motivations, the formation of purchase intentions, and the influence of socio-cultural factors on consumer behavior. Nevertheless, most scientific research focuses on markets in general or on specific product groups without addressing the unique characteristics of organic fruit preserves, leaving a clear niche for in-depth study of this segment.

Modern models of consumer behavior are widely applied across various areas of marketing research. However, none of them comprehensively addresses all the determinants of consumer behavior in the organic products market, where consumer decisions are especially complex – integrating economic, moral-ethical, social, and emotional motives. This creates the need for new, combined models that can more accurately predict consumer behavior in specific organic product markets.

Contemporary studies (Murphy et al., 2022) highlight the pivotal role of consumer trust in organic certification systems across several European countries, emphasizing that credibility and transparency are key to maintaining consumer loyalty in this segment. Meanwhile, other researchers (Madureira et al., 2025) provide a detailed assessment of consumer purchasing behavior in Greece, underscoring the influence of health and environmental awareness on demand for organic foods.

Recent works (Muska et al., 2025; Bocean, 2025) offer broader perspectives on the policy and environmental significance of expanding organic agriculture in the EU, directly linking agricultural practices to greenhouse gas emissions and environmental sustainability. These works justify the relevance of promoting organic food not only as a consumer choice but also as a systemic strategy for sustainable development.

From the Ukrainian context, Kupalova and Demchenko investigate the preconditions for ecological modernization in Ukrainian enterprises, identifying motivational and regulatory drivers for implementing environmentally friendly technologies. Their findings support the idea that businesses' transition toward sustainability aligns with broader European Green Deal goals – thus indirectly reinforcing market readiness for organic production (Kupalova, & Demchenko, 2023). Furthermore, the

study by Pryhara and Yarosh-Dmytrenko analyzes how Ukrainian businesses adapt to turbulent wartime conditions through strategic flexibility, diversification, and process optimization – all of which are also relevant for exporters targeting demanding international markets such as the UK (Pryhara, & Yarosh-Dmytrenko, 2023).

Thus, prior research highlights the importance of trust, certification, sustainable practices, and adaptive business strategies. Yet, despite growing interest in sustainability and organic consumption, a distinct gap remains in models that fully account for behavioral, motivational, and cultural factors specific to organic fruit preserves. Addressing this gap, the present research proposes and tests a comprehensive consumer behavior model tailored to the UK market, focusing on the organic fruit preserves segment – a relatively underexplored niche.

Methods

The methodological basis of the study includes the dialectical method of scientific cognition, as well as analysis and synthesis, historical and logical approaches, scientific abstraction, and systems analysis - applied in defining the essence of the concept of "consumer behavior" and in developing a model of consumer behavior. A structured tabular analysis of business environment factors (STABS methodology) was used for the selection and expert assessment of the impact of international business environment factors on the activities of organic product producers (Starostina, & Kravchenko, 2022). In addition, induction and deduction methods, together with the hypothetical method, were employed to develop hypotheses regarding the influence of market problems and opportunities on factor dynamics. Methods of rating assessments, statistical comparisons, and comparative analysis were applied to determine the attractiveness of international markets. Quantitative and statistical methods supported the collection and analysis of primary marketing information, while the survey method was used to gather primary data directly.

Results

The current state of economic science demonstrates that consumer behavior is increasingly understood as a multifaceted process shaped by the interaction of external business environment factors – political and legal, economic, demographic, environmental, scientific and technical, and cultural – and internal factors, such as an individual's system of values, motives, beliefs, and emotional states. This interpretation is particularly relevant in the organic products market, where consumer choice is influenced not only by economic feasibility or rational criteria but also by value orientations, ethical principles, and the pursuit of individual or social self-realization (Thøgersen, 2010).

Within this market, a hybridity of motivations can be observed: alongside traditional factors such as price and quality, moral attitudes and emotional considerations play a crucial role (Hassett et al., 2025). These include a sense of participation in environmentally safe and sustainable consumption, as well as the desire to engage in socially approved behavior (World Economic Forum, 2021)

In both international and domestic scientific literature, considerable attention has been devoted to the study of consumer behavior. Through the generalization of existing approaches, several key concepts have been identified that are widely applied in predicting consumer behavior:

- Isaac Ajzen's Theory of Planned Behavior (TPB) is widely applied in the study of consumer intentions, as it explains the influence of personality traits, subjective social norms, and

perceived behavioral control on decision-making (Canova, Manganello, & Bobbio, 2020). However, the model has limitations in contexts where behavior is strongly driven by emotional impulses or spontaneous decisions, as is often the case in the organic food market. Although TPB is already commonly used in organic food research, scholars recommend expanding it to include moral and habitual variables.

- The Value-Belief-Norm (VBN) Theory, proposed by Paul Stern, enables the analysis of the moral and ethical foundations of consumer behavior. Nevertheless, its predictive power is limited when consumers face high prices or lack reliable information. The theory is valuable for assessing personal norms – such as whether individuals feel they "should" buy organic products – but requires supplementation with health-related and external factors (Horn, & Wehrmeyer, 2020).

- The Health Belief Model (HBM), developed by Irwin M. Rosenstock and Godfrey M. Hochbaum, predicts health-related behavior based on perceived threat (a combination of vulnerability and problem severity), expected outcomes, the presence of external incentives, and self-efficacy. This model is particularly useful for identifying whether organic consumption is hindered by insufficient knowledge (low perceived vulnerability) or by cost (high barriers). However, for a more comprehensive understanding of consumer behavior, it should be combined with social and environmental motives (Alyafei, & Easton-Carr, 2024).

- Social Cognitive Theory (SCT), developed by Albert Bandura, provides a broad framework that views human behavior as the result of interaction between personal and

environmental factors. It is useful for examining the role of environment, habits, and accessibility. Yet, because SCT is a general framework rather than a precise causal model, it can be too broad or vague in application. Without clearly defined hypotheses, it may be difficult to determine which factors should be measured (Bandura, 1971).

- Finally, B. J. Fogg's Behavioral Model (FBM) outlines a clear set of conditions for action: increasing motivation, simplifying the behavior, and adding a trigger. It emphasizes the critical role of triggers, which can stimulate action even under conditions of low motivation or limited resources. While this model is valuable in capturing spontaneous behavior and has already been applied in sustainability contexts (Soyer, & Ditttrich, 2021), it does not sufficiently account for the social context of decision-making.

Based on the analysis, it was concluded that none of the existing models, in their isolated form, are sufficient to predict consumer behavior in the organic fruit preserves market. This can be explained by the unique characteristics of this segment, where consumer choice results from the simultaneous influence of rational considerations, moral and ethical principles, social pressures, and emotional factors. This market is characterized by high demands for ecological purity, consumer sensitivity to price fluctuations, the desire to demonstrate socially responsible behavior, and the need to feel satisfaction from consuming a product positioned as the "right" or "ethical" choice.

As a methodological foundation for developing a comprehensive model of consumer behavior for organic products, the theory of planned behavior, the values-beliefs-norms theory, and the Fogg model were selected (Fig. 1).

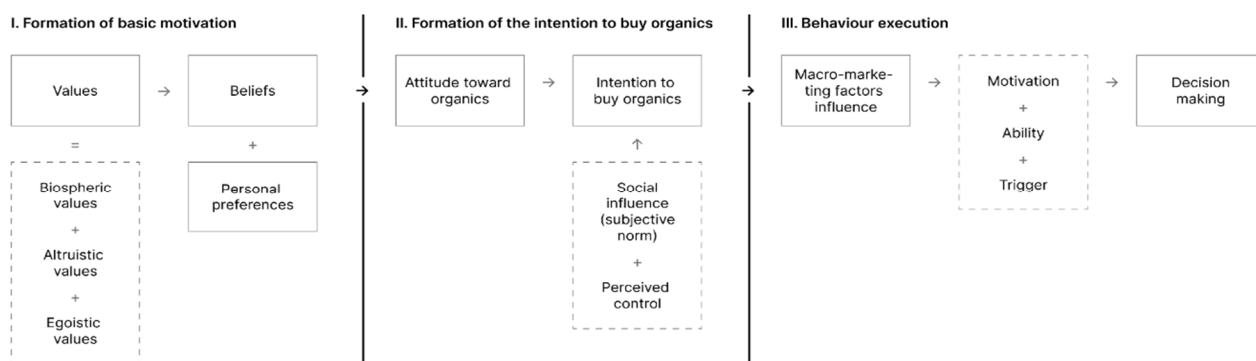


Fig. 1. Graphical representation of a complex model of consumer behavior for organic products

The structure of this model involves combining a cognitive level, which includes a rational assessment of benefits, risks, and product quality, with a value level, where moral attitudes, environmental beliefs, and personal norms prevail. At the same time, the emotional level reflects factors such as a sense of pride in environmentally responsible behavior or the desire for social approval, while the trigger level describes the mechanisms that motivate consumers to take immediate action under the influence of advertising messages, packaging design, or brand activity on social networks.

This approach makes it possible to account for both rationally determined consumer decisions and emotional or situational reactions. This is especially relevant in the organic products market, where decisions are often made not only from the standpoint of personal benefit but also based on values and emotions.

For the practical implementation of this model, two international markets were selected through comparative analysis: Denmark and the United Kingdom, both of which are considered highly promising for the export of organic fruit

preserves. A common feature of these markets is the high level of environmental awareness among the population and the willingness of consumers to pay premium prices for products that meet organic standards.

At the same time, there are significant differences between them. The British market is characterized by strong emotional involvement: when making purchasing decisions, consumers attach great importance to the brand's history, its social mission, and visual elements of the packaging, which create an emotional connection with the product. In contrast, consumer behavior in Denmark is more pragmatic, focusing primarily on the price-to-quality ratio and relying less on emotional stimuli or brand image.

Based on the results of the comparative analysis, four summary tables of market threats and opportunity factors were compiled for the United Kingdom and Denmark (Starostina et al., 2021). The threats and opportunities that received the highest expert evaluation are considered the most significant for making market entry decisions (Table 1).

Table 1

**Summary table of market threat and opportunity factors for the UK and Denmark
for organic fruit preserves manufacturers (shortened)**

No	Factors	Expert score assessment of the significance of the factor (1–10)	Hypothesis of influence on the action of a factor	Demand (+)	Supply (+)
Great Britain (threats)					
1.	<i>General competitive situation in the market</i>				
1.1	High competition from foreign suppliers	8×30=240	Promotional measures focus on unique positioning and value for money	+	
2.	<i>A complicated certification process and obtaining permits for importing organic products</i>				
2.1	Update to the EEA trade agreement on the mandatory certificate of inspection	6×25=150	Using the Product tool – paying additional attention to quality parameters during production to meet certification requirements		+
3.	<i>Differences in the role of organic products in consumers' daily diets</i>				
3.1	Perception of organic products as a luxury item in the UK	3×20=60	Using the Promotion tool as part of a marketing mix to combat British prejudice against organic products	+	
X	Total	450			
Great Britain (opportunities)					
1.	<i>Rising consumer price index amid the cost-of-living crisis</i>				
1.1	UK consumer price index up 4% over the last 12 months	9×30=270	Promotional measures, focus on unique positioning and price-quality ratio, low price strategy	+	
2.	<i>Growth of the organic food market</i>				
2.1	The UK organic food and beverage market grew by 2% in 2023	9×30=270	Promotional activities focus on unique positioning and value for money	+	
3.	<i>Average wage growth</i>				
3.1	Average monthly earnings in the UK increase by 6.5%	8×30=240	Using the Promotion tool to increase consumer awareness of the manufacturer's products	+	
4.	<i>Easing customs restrictions for Ukraine due to the full-scale invasion</i>				
4.1	Signing of an agreement with Great Britain on the continuation of duty-free trade with Ukraine	8×25=200	Redirecting funds paid for duties to promotion to increase product awareness		+
...	...	...	...	...	...
X	Total	1260			
Denmark (threats)					
1.	<i>Rising consumer price index amid the cost-of-living crisis</i>				
1.1	Denmark's consumer price index rises by 5% year-on-year compared to April 2023	9×30=270	Promotional measures, focus on unique positioning and price-quality ratio, low price strategy	+	
2.	<i>Growth of the organic food market</i>				
2.1	By 2028, the organic market in Denmark will reach \$7.56 billion	9×30=270	Promotional measure, focus on unique positioning and value for money	+	
3.	<i>General competitive situation in the market</i>				
3.1	High competition with local producers and imports	9×30=270	Promotional measures focus on unique positioning and value for money	+	
4.	<i>A complicated certification process and obtaining permits for importing organic products</i>				
4.1	Changes to EU regulations on strengthening control over supply chains	7×25=175	Using the Product tool – paying additional attention to quality parameters during production to meet certification requirements		+
...	...	...	...	...	...
X	Total	1045			
Denmark (opportunities)					
1.	<i>Average wage growth</i>				
1.1	In 2023, the average monthly salary in Denmark increased by 3.5%	8×30=240	Using the Promotion tool to increase consumer awareness of the manufacturer's products	+	
2.	<i>Easing customs restrictions for Ukraine due to the full-scale invasion</i>				
2.1	The European Commission has continued the abolition of import duties on agricultural goods from Ukraine	8×25=200	Redirecting funds paid for duties to promotion to increase product awareness		+
3.	<i>Strengthening government support for organic production</i>				
3.1	The Danish Parliament approved the creation of a new fund for the development of organic farming	6×25=150	Using the Promotion tool to strengthen the positions of Ukrainian producers	+	
4.	<i>Differences in the role of organic products in consumers' daily diets</i>				
4.1	The tradition of organic consumption is deeply rooted in the mentality of the Danes	5×20=100	Increasing consumer awareness and building a long-term reputation	+	
...	...	...	...	...	...
X	Total	795			

The summary tables show that the UK market is more attractive for Ukrainian producers of organic farm products: 1,260 points of market opportunities for the UK versus 795 for Denmark, and 450 points of market threats for the UK versus 1,045 for Denmark.

Thus, for Ukrainian producers, the UK market appears more promising due to its significantly larger volume of organic product imports, the steady interest of consumers in foreign brands, and the positive perception of organic products from European countries.

The information base for identifying consumer behavior patterns was formed through the collection of primary marketing data via a questionnaire survey of the UK population. The survey was conducted online using the Google Forms platform in February 2024, with a sample of 40 respondents. The results showed that 65% of respondents demonstrate a predominantly positive attitude toward organic products and consider them safer for health (Fig. 2).

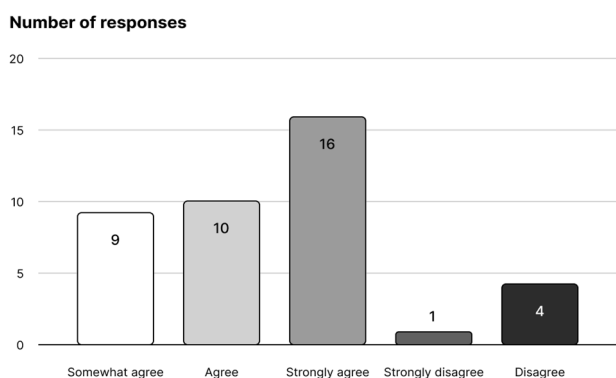


Fig. 2. Chart showing responses to the question: "To what extent do you agree with the statement: 'Organic products are healthier than conventional products?'"

This indicates that the majority of respondents are convinced of the advantages of organic products, confirming the formation of a cognitive attitude, which is the main precursor of the intention to act.

Furthermore, 73% of respondents expressed their willingness to pay more for organic fruit preserves compared to conventional alternatives (Fig. 3).

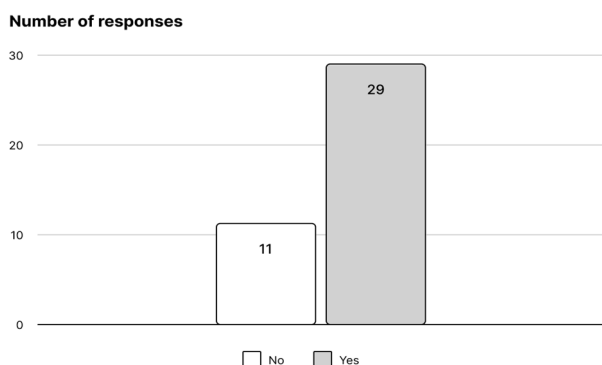


Fig. 3. Chart showing responses to the question: "Are you willing to pay extra for organic fruit preserves compared to conventional ones?"

This result confirms a high level of readiness for action, reflecting the transition from the motivational stage to the formation of intention, according to the model. The fact that more than a quarter of respondents are not willing to pay more indicates the presence of a price barrier. While not

critical, this barrier requires either product price segmentation or the visualization of added value in marketing communication.

Respondents also assessed the importance of three types of positive effects from consuming organic products (Fig. 4). The highest rating was given to the health of family members (8.8), followed by personal health (7.5) and environmental protection (6.6).

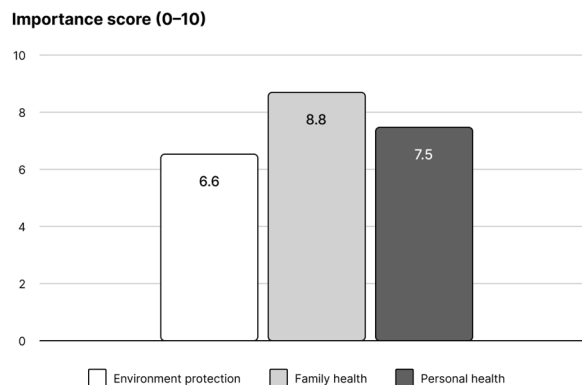


Fig. 4. Chart showing responses to the question: "Which of the positive effects of consuming organic fruit preserves are the most significant for you?" (mean importance scores on a 10-point scale)

According to the structure of motivations in the model, altruistic values prevail, egocentric values remain consistently high, while biospheric values are the lowest priority, though still present. Therefore, communication should emphasize personal consequences and the safety of loved ones.

Respondents also evaluated the importance of three groups of parameters (Fig. 5). The highest priority was quality (4.6 points), followed by price (4.0 points), and, in third place, additional parameters with a score of 2.8 points.

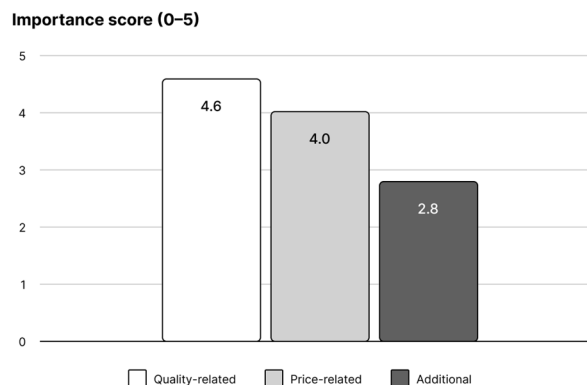


Fig. 5. Chart showing responses to the question: "Which of the following parameters of organic fruit preserves are most important to you when buying?" (mean importance scores on a 5-point scale)

Consumers are seeking the best price-to-quality ratio, rather than simply choosing the lowest cost option.

With regard to quality parameters, respondents rated the naturalness of ingredients the highest, 8.9 points out of 10 (Fig. 6). This was followed by health benefits (8.5 points) and the absence or reduction of sugar content (7.5 points). Next in importance were taste (7.4), absence of impurities (7.4), and appearance (6.6).

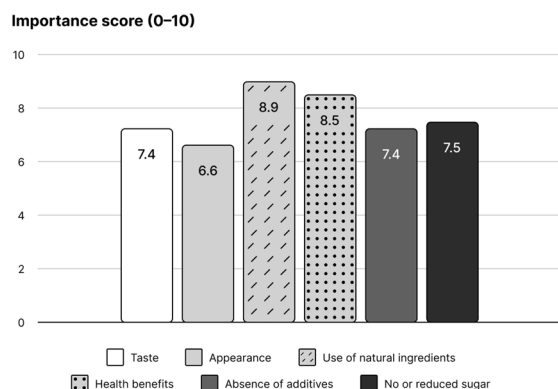


Fig. 6. Chart showing responses to the question: "Which of the following quality parameters are most important to you when choosing organic fruit preserves?" (mean importance scores on a 10-point scale)

It was concluded that consumers are primarily focused on the composition and functional benefits of the product. The high scores for "naturalness" and "health benefits" indicate the need for a product that can be trusted, while the importance of "low sugar content," "absence of impurities," and "taste" reflects attention to overall dietary quality, not just the declared organic status.

Regarding additional benefits (Fig. 7), the highest importance was given to international certification (8.5 points), followed by the country of origin (7.9 points) and discounts (7.5 points). Environmentally friendly packaging received a score of 7.4 points, while the least important factors were the "take-away" format (5.2 points) and brand image (4.7 points).

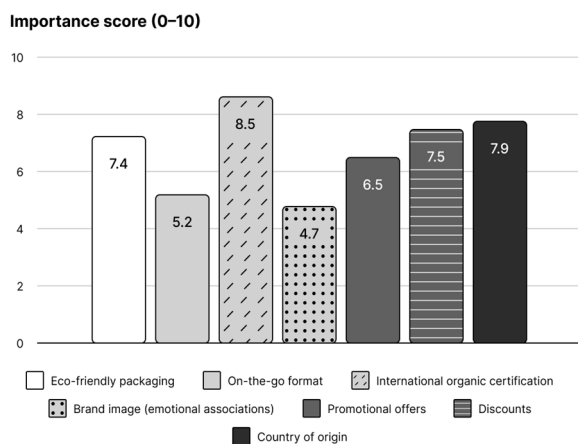


Fig. 7. Chart showing responses to the question: "Which of the following additional parameters are most important to you when choosing organic fruit preserves?" (mean importance scores on a 10-point scale)

The results show that even additional parameters are evaluated from a rational perspective: above all, the presence of official quality confirmation (certificates) and the transparent origin of the product are considered most important. A high assessment of discounts and promotions indicates continued price sensitivity, even within the segment of consumers loyal to organic products. In contrast, "brand image" and "format" are perceived as secondary, highlighting the limited role of brand associations in shaping the final purchasing decision. Overall, consumer behavior is centered on the intrinsic value of the product.

Most consumers are willing to pay within the mid-premium segment (Fig. 8), namely £3.50–4.00 per unit of jam. Responses also included higher prices (up to £5.20) and lower prices (as low as £2.70), which demonstrates the presence of price-sensitive consumers.



Fig. 8. Chart showing responses to the question: "What price do you consider fair for a jar of organic raspberry jam in a 150g package?"

It is reasonable to focus on the average figure of £3.78. The study results confirmed the importance of the emotional factor in consumer decision-making. Many respondents noted that choosing organic products is, above all, a way to express their stance on environmental protection, care for personal health, and social responsibility. This finding underscores the need to account for the emotional component when developing marketing strategies.

Recommendations were formulated for Ukrainian producers of organic fruit preserves, particularly for the company Dunaysky Agrariy, regarding entry into the UK market. The main directions of the promotion strategy include creating emotionally driven brand positioning that communicates a social mission, emphasizes environmental responsibility, and tells the story of the brand as a bearer of sustainable development values. It is also recommended to actively employ packaging design as a tool for emotional consumer engagement, alongside differentiated pricing for various market segments by offering both premium and more affordable product lines. An important aspect of the strategy is the organization of tasting events and information campaigns aimed at increasing consumer awareness of Ukrainian organic products. Furthermore, it is advisable to establish partnerships with local retailers and online platforms to ensure broader access to the target consumer segment.

Overall, the study results demonstrate that adopting a combined model of consumer behavior provides manufacturers with an effective tool for adapting marketing strategies to the specifics of the target market. Such an approach takes into account not only economic parameters but also the value-emotional components of consumer behavior, which play a decisive role in the organic segment.

Discussion and conclusions

The analysis of the research results confirms that the behavior of consumers of organic fruit preserves is shaped by a far more complex system of motivations than classical economic models suggest. The primary aim of this study was to clarify the nature and structure of the determinants influencing consumer decisions in an international context, particularly in the United Kingdom. The questionnaire findings indicate that the main drivers of purchasing behavior are not strictly rational factors such as price or availability, but rather deeper aspects – trust in the brand, ethical perceptions of

production, environmental responsibility, and personal identification with certain social values.

As part of the research, a systematic analysis was conducted of five of the most relevant theoretical models used to explain and predict consumer behavior: the Theory of Planned Behavior (TPB), the Values-Beliefs-Norms (VBN) Theory, the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Fogg Behavior Model (FBM). However, only three – TPB, VBN, and FBM – proved to have sufficient potential for explaining consumer behavior in the organic products segment, as they account for not only rational attitudes but also emotional and value-based factors.

By analyzing the factors of the macromarketing environment and conducting a marketing survey, it was possible to identify and evaluate the main marketing opportunities and challenges, while also correlating the empirical results with the theoretical interpretation of motivational mechanisms within the developed model of consumer behavior. This process confirmed the explanatory power of the model, making it a useful tool for further analysis of consumer behavior in the organic products segment.

The results carry significant practical value for Ukrainian producers seeking to expand their presence in international markets, particularly in the UK. The empirical data collected through the survey provides a clearer understanding of consumer behavior patterns for organic fruit products, enabling companies to make timely and flexible adjustments to marketing strategies in response to specific cultural and economic contexts.

The findings suggest that Ukrainian companies aiming to integrate into export markets for organic products should concentrate on building branding elements that foster both emotional and behavioral resonance with their target audience. This may involve aspects such as the visual design of labels, highlighting the unique story of the producer, and demonstrating ethical production standards through communication on social media and other platforms. Implementing these changes does not require capital-intensive transformations of the production process, but rather a deeper understanding of consumer motivations and expectations.

It should also be emphasized that the model applies not only to the fruit preservation segment but also to other categories of organic products, including dairy, grains, and legumes. The practical application of the model allows Ukrainian companies to develop a more accurate understanding of consumer expectations, thereby contributing to the overall export potential of the organic industry.

Thus, this study offers direct applied value for Ukrainian agribusinesses seeking not only to comply with European quality standards but also to position themselves within the broader discourse of ethical, sustainable, and responsible production. Integrating behavioral models into strategic planning enables a shift from a purely mechanistic approach to product promotion toward a more sophisticated system of interaction with consumers as carriers of cultural, ethical, and emotional values. This represents the greatest potential of the recommendations proposed in the study.

Methodological limitations and prospects for further research. Despite achieving the research objectives and obtaining several practically relevant results, the study has several objective methodological limitations that must be considered when interpreting the findings and planning future empirical initiatives.

First, it is necessary to acknowledge the limited sample size of respondents who participated in the questionnaire survey. Although the quantitative composition of the sample

($n = 40$ valid responses) meets general standards for descriptive statistical studies, it is not fully representative of the entire consumer base in the United Kingdom. In particular, most respondents were active users of digital platforms, residents of large cities, and individuals with a higher level of interest in sustainable consumption. This indicates a potential self-selection effect, which may have amplified "environmentally positive" responses and, consequently, introduced some bias into the results. Future studies would benefit from employing a stratified sample that includes a broader range of socio-demographic groups, such as rural residents, lower-income individuals, and those with limited digital activity.

A second notable limitation is the format of the study – the survey was conducted exclusively online. To achieve deeper insights, it would be advisable to adopt mixed data collection methods, such as focus groups and semi-structured in-depth interviews. These approaches would allow for a more nuanced understanding of the hidden logic behind consumer behavioral decisions.

A further limitation concerns the descriptive nature of the statistical analysis. In this study, the focus was placed on descriptive measures such as frequencies, averages, and correlations. While this approach reveals general trends, it does not enable a full assessment of causal relationships or the identification of latent structures underlying behavioral variables.

To capture broader patterns, future research should include comparative analyses with other countries, such as the Netherlands, Germany, France, and the Scandinavian nations, where demand for organic products is also on the rise.

Finally, advancing this line of inquiry requires not only expanding the sample and refining statistical procedures but also embracing methodological openness. For instance, neuromarketing techniques, which assess unconscious reactions to visual or auditory stimuli, could substantially enrich our understanding of the effectiveness of behavioral triggers within the FBM model.

Within the framework of the conducted research, it was possible to achieve the key goal – to develop an applied model of consumer behavior of organic fruit products, taking into account ethical, value, cognitive, and situational determinants. The experience of Great Britain and Denmark, which were considered as demonstration markets with a high level of environmental awareness, made it possible to identify the main patterns in consumer motivation, determine the factors influencing decision-making, and formulate adaptive strategies for Ukrainian producers. As a result of the synthesis of theoretical models TPB, VBN, and FBM, a combined concept was proposed, which demonstrates high explanatory power in the context of the analysis of behavioral patterns in the field of organics.

An expanded interpretation of consumer behavior as a multidimensional process with moral-ethical, emotional, and rational dimensions became the basis for rethinking the marketing approaches used by Ukrainian producers. The study substantiated that for successful entry into the international market, it is not enough to meet technical standards – the decisive role is played by the brand's value identity, transparency, ability to inspire trust, and resonance with consumer expectations regarding ethics, sustainability, and authenticity.

The results obtained confirm that consumer loyalty in the organic segment is formed not only on the basis of product quality, but also through a dialogue of values between the brand and the consumer. Therefore, the developed strategy for entering the UK market by the company Dunaysky

Agrariy focuses on the importance of building a communication platform based on emotional triggers: the history of origin, the visual appeal of the packaging, and associations with naturalness and social responsibility.

The significance of this study goes beyond the narrowly specialized subject. It illustrates the general economic trend of transforming the paradigm of market relations: from the economy of quality to the economy of trust, where products are perceived not only as the result of production, but also as a marker of culture, brand position, and reflection of the consumer's worldview.

The proposed model is adaptable and suitable for use not only in the agricultural sector, but also in a broader context – for example, for analyzing the behavior of consumers of eco-products or ethical fashion. Thus, the study contributes not only to the field of marketing but also to behavioral economics and applied sociology. The scientific value of the work lies in the combination of theoretical generalization, empirical verification, and practical orientation of the results.

The study confirms that behavioral models, enriched with value-ethical categories, allow not only for more accurate predictions of consumer reactions, but also for the formation of effective strategies for interacting with them in the dynamic environment of the organic market. Its results are relevant, scalable, and practically applicable, especially in the context of the tasks of Ukraine's economic integration into the EU markets, where quality, trust, and sustainability are the determining criteria for market success.

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МОДЕЛЬ ПОВЕДІНКИ СПОЖИВАЧІВ ОРГАНІЧНОЇ ПРОДУКЦІЇ: ЕМПІРИЧНЕ ДОСЛІДЖЕННЯ РИНКУ ВЕЛИКОЇ БРИТАНІЇ

Вступ. Зростання попиту в країнах світу на органічні продукти зумовлене посиленням екологічних проблем і зміною споживчих пріоритетів на користь безпечних і сталих товарів. Ринок органічної продукції формується під впливом системи економічних, соціальних і культурних чинників, що обумовлює необхідність детального вивчення моделей поведінки споживачів на міжнародних ринках. Метою дослідження є удосконалення теоретичних підходів та розроблення практичних рекомендацій щодо використання моделей споживчої поведінки як основи ефективних стратегій діяльності суб'єктів зосподарювання на міжнародних ринках органічної продукції для сприяння сталому розвитку економіки України. Об'єктом дослідження є економічні відносини між виробниками та споживачами на міжнародних ринках органічної продукції. Предмет дослідження містить теоретичні та методичні аспекти формування моделей поведінки споживачів на міжнародних ринках органічної продукції.

Методи. Дослідження ґрунтується на комплексному застосуванні загальнонаукових (аналіз і синтез, індукція, дедукція, аналогія та порівняння, класифікація, систематизація, кількісні та статистичні тощо) та конкретно-наукових (гіпотетичний, створення теорії, візуальний і графічний) методів, що дало змогу поєднати теоретичний аналіз з емпіричними спостереженнями для реалізації мети дослідження.

Результати. Установлено, що жодна з проаналізованих моделей споживчої поведінки у вітчизняній і світовій економічній літературі окремо не розкриває всі аспекти поведінки споживачів органічної продукції. Розроблено комплексну модель, яка поєднує когнітивні, емоційні та ціннісні аспекти формування споживчого наміру та його реалізації у поведінці, що стала основою розроблення стратегії просування компанії "Дунайський аграрій" на ринок Великої Британії. Виявлено позитивні соціальні й екологічні ефекти розвитку органічного сектору для економіки України.

Висновки. Запропонована модель є інструментом для прогнозування поведінки споживачів і може бути використана як основа для розроблення системи просування продукції на міжнародних ринках. Отримані результати мають практичну цінність для українських виробників органічної продукції та сприятимуть підвищенню конкурентоспроможності України на світовому ринку та переходу на модель сталого розвитку.

Ключові слова: органічна продукція, сталий розвиток, споживча поведінка, моделі споживчої поведінки, СТАБС-аналіз, моделі ділової культури, просування, гнучкі екстрені рішення.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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CURRENT CHALLENGES IN FINANCING HIGHER EDUCATION

Background. The key foundation for the qualitative development of a country's economy lies in the level of advancement of its education and science. Amid current challenges, this is critically important for the country's survival. The state of education and science in Ukraine largely depends on the availability of funding resources, the search for successful international models, and their implementation and adaptation to the country's present realities. It is also essential to apply rigorous criteria when prioritizing funding for education and science. The aim of this study is to analyze the state of higher education financing in Ukraine, its relationship with the Human Development Index, and to explore possible trajectories for further development of this sector.

Methods. To achieve the research objectives, the study employed methods of analysis and synthesis (generalization and identification of key aspects), statistical analysis (processing data on the current state of higher education financing), and graphical methods (for visual representation of the studied processes).

Results. The article analyzes the financing of higher education as a critically important factor in developing Ukraine's knowledge-based economy. It identifies the link between education funding, the Human Development Index, and the country's innovation potential. The paper examines international practices-specifically, Germany's competitive grant-based funding model and Israel's strategy for building a "startup nation." It highlights key domestic challenges: low efficiency of resource use, a lack of innovative financial mechanisms, and weak integration of science into the global arena. The need for infrastructure investment and support for high-potential universities is substantiated.

Conclusions. The study concludes that the development of a knowledge economy requires high-quality education and effective financing, including transparent use of public funds and encouragement of student loan systems. Major challenges include the absence of innovative financial mechanisms, weak business investment activity, and poor integration of Ukrainian science into the global research space, all of which reduce resource efficiency. A breakthrough in education demands investment in universities' infrastructure, optimized budget spending, and support for institutions with strong development potential.

Keywords: innovative development, investment, Human Development Index, innovation potential, higher education financing models.

Background

The current situation in Ukraine compels institutions in the fields of education and science to seek alternative means of financing higher education amid declining state revenues. This raises critical questions about the accessibility of educational services for all citizens.

Since gaining independence in 1991, Ukraine's approach to education financing has been shaped by numerous factors, including the transition to a market economy, the introduction of private property, and the implementation of program-targeted and formula-based methods for allocating budgetary resources. These developments have been further complicated by political upheavals, including revolutions, annexation, and a full-scale invasion.

There is sufficient research in the scientific literature on financing higher education in developing countries, because Ukraine belongs to this group. Thus, researchers Alper Goksu and Gonca Gungor Goksu (Goksu A., & Goksu G., 2015) note in their work that each country uses a different model of financing higher education with varying levels of success. This group of countries is predominantly private-sector funding. The public sector's contribution to higher education funding varies considerably across countries. Recently, significant changes have occurred in many countries' higher education systems. As a result of developments in this area, the balance between private and public sector contributions to higher education funding has changed.

In the current study, the authors discuss the different applications of higher education funding systems and analyze the contributions of other actors involved in higher education funding. The importance of having effective mechanisms for financing higher education that ensure equitable outcomes and economic viability is discussed in their studies by Chapman and Dearden (2021). The authors raise the issue of accessibility to higher education through

such an instrument as a student loan and argue for the feasibility of targeted assistance to all disadvantaged potential students for reasons of social justice and the importance of creating the right funding system. Patrick Clancy's Investing in Education (Clancy, 1996) became a foundational document for educational policy in the era of economic planning that began in the late 1950s. Researchers Loxley, Seery, & Walsh (2014) consider it to disseminate theories of human capital formation. Investing contributed to a significant shift in educational policy, based on a widespread belief among politicians, government officials, and international advisors that education was key to a country's economic salvation. This paradigm shift was driven by domestic priorities shaped by past economic failures and broader international trends inextricably linked to the Cold War. Education and technological development were given special importance as key areas of struggle in the global confrontation between the capitalist West and the Soviet Union.

The main ideas of "Investment" – in particular, increasing funding for education as a necessary condition for economic development, as well as expanding access to post-secondary and higher education to overcome the shortage of qualified personnel – became central to Irish education policy for two generations after the publication of this work. These are the quantitative trends analyzed in the article. Zhao (2001) examines the impact of diversification of funding sources on the quality of higher education, and concludes that a diversified funding scheme improves the current difficult financial situation in higher education. The author notes that the funding shortfall has affected the infrastructure of higher education and the quality of teaching and learning. Also, the higher education level is evaluated by the results of its achievement of economic and social goals, as well as the short-term and long-term interests of

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the nation. Chattopadhyay (2007) argues that higher education is the key to leadership in knowledge production. How higher education is financed is crucial for understanding how higher education is provided to society and at what cost. The importance of exploring alternative sources of financing for higher education remains relevant. Leshanyc, Miahkykh, & Shkoda (2018) conducted a comparative analysis of financing models for higher education institutions in Ukraine and foreign countries, which became the basis for developing the most promising areas of development of domestic legislation in this area, and also noted that the implementation of foreign experience will make financing more transparent and provide an opportunity to distribute it by the criteria for the quality of educational services and will contribute to the active attraction of investments in education, training and high technologies.

Chattopadhyay (2007) argues that higher education is the key to leadership in knowledge production. The method of financing higher education is crucial for understanding how higher education is provided to society and at what cost. The importance of studying alternative sources of financing for higher education remains relevant.

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Pisarska (2020), in her study, emphasizes the structure of sources of financing of the studied higher educational institution in the context of modern conditions of its functioning. In particular, the study provides an understanding of the share of state higher education institutions' financing in the general flow of financing their activities. The increase in the share of financial resources from the commercialization of research results in the total volume of financing of tasks, which demonstrates the growing importance of the entrepreneurial idea of the university, which has recently been one of the main types of university activity.

In their study, Ukrainian researchers Tereshchenko and Oleinikova (2017) explored the development pathways of the higher education system in EU countries. They found that the increase in the volume of state funding is inherent in more developed nations with an innovative model of economic development, where developed countries not only pay significant attention to the development of the higher education system but also allocate a significantly larger share of expenses in favor of secondary and post-secondary non-higher education (work qualification). They also analyzed the current model of financing education in Ukraine and formulated the main financing problems.

At the same time, scientists Starostina and Kravchenko (2024) in their research raise the issue of developing mechanisms for transferring scientific knowledge to business by improving the quality of education and integrating research into the educational process.

The stability of the national system depends on many factors, especially in wartime, and one of the key ones is financing, as noted in their study by Kuklin, Azmuk and Dernova (2023). The team of scientists draws attention to

the fact that the domestic higher education system still has a significant margin of safety and proposes directions for post-war reform of the national higher education system based on resilience.

The publication of Bazhenova (2023) is devoted to the issues of post-war reconstruction of the economy of Ukraine, where the author concludes, when analyzing the growth rates of the economies of Japan, the Republic of Korea and Israel during 1951–2019, that one of the decisive drivers of economic growth is the provision of quality education, which leads to an increase in the level of human capital.

The aim of this study is to analyze the current state of higher education financing in Ukraine, examine its relationship with the Human Development Index (HDI), and identify potential trajectories for the future development of this sector.

Methods

The study employs a combination of analytical and statistical methods. Analytical methods include synthesis and generalization, with a focus on identifying key research perspectives. Statistical methods involve the processing and interpretation of data on the current state of higher education financing. Additionally, graphical analysis was used to visualize and interpret trends and patterns.

Results

To optimize the process of providing and functioning of higher education, it is necessary to understand the operation of the financial support mechanism, where all links are interconnected and essential. Our issue concerns the multiplicity of sources of financing for higher education, where the key forms are budget financing, self-financing, and lending. Budget financing – budget funds that are limited and are directed to cover part of the expenses of the relevant higher education institution. Self-financing – covering expenses at the expense of one's resources, which include fees for the provision of educational services, income from economic and/or production activities, rental income, grant income, and funds from patrons and benefactors. Lending – attracting loan resources on maturity, payment, security, and targeted use. These forms allow higher education institutions to perform the functions assigned to them by the state and contribute to the creation of added value in the country's economy.

To a certain extent, forms of financing are a manifestation of investment in higher education, because they have all the characteristics inherent in this phenomenon. According to the Law of Ukraine "On Investment Activities", investment is all types of property and intellectual values invested in objects of entrepreneurial and other kinds of activity, resulting in profit and/or a social and environmental effect. As for the payback of such investments, they can only be certain types of activities, and the entire complex of university activities, such as scientific research, education, and public platforms, will not have financial profit in the classical understanding of this phenomenon. However, we are talking about a macroeconomic effect, which is achieved at the country level. After all, obtaining higher education by a large number of the population allows us to talk about the training of highly educated specialists who, in the future, will bring precisely this financial effect at the country level. This is the basis of the quality of human potential and innovative development.

The Human Development Index (HDI) is a generalized indicator of average achievements in key aspects of human development: a long and healthy life, awareness, and a decent standard of living (Fig. 1).

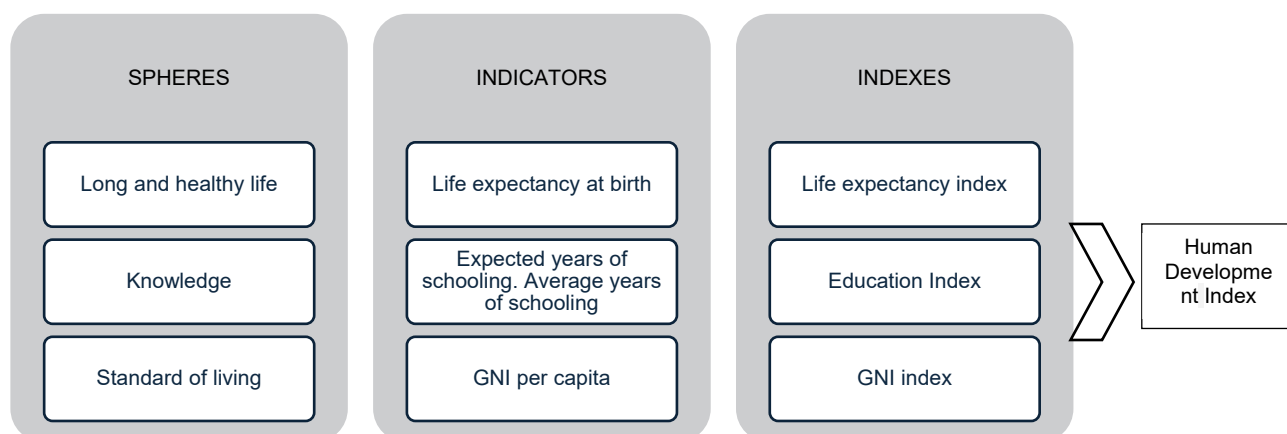


Fig. 1. Components of the Human Development Index

Source: visualized by the author based on data from the Human Development Report.

The HDI is calculated as the geometric mean of the normalized indices for each of the three dimensions. The health dimension is measured by life expectancy at birth, the education dimension by the average years of schooling for adults aged 25 and over, and the expected years of education for children starting school. The standard of living is measured by gross national income (GNI) per capita. The

HDI can be used to analyze national policies, particularly considering how two countries with the same GNI per capita can have different human development outcomes. Such comparisons can stimulate discussions about public policy priorities. Ukraine performs above expectations regarding development in the HDI ranking (Fig. 2).

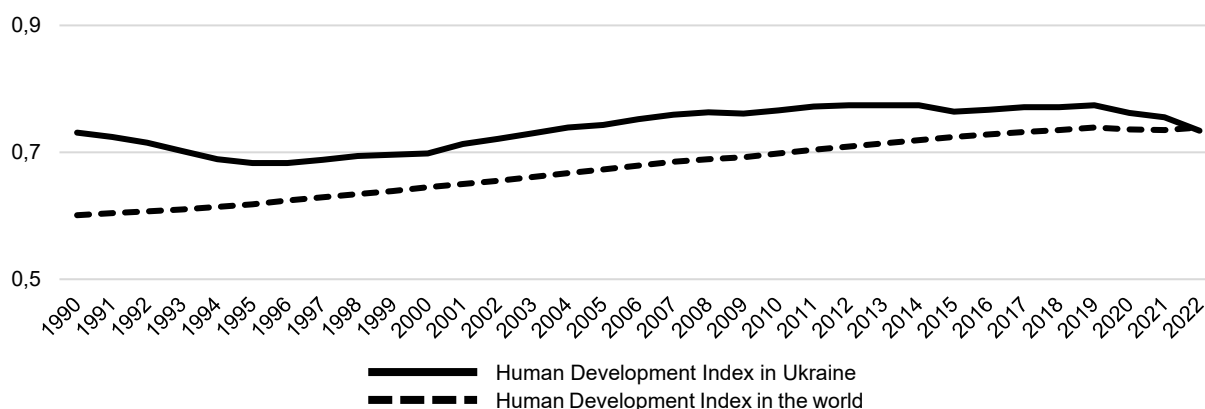


Fig. 2. Human Development Index in Ukraine and the world, 1990–2022

Source: constructed by the author based on data from the Human Development Report.

The second important ranking is the Global Innovation Index. The Global Innovation Index (GII) was created with the World Intellectual Property Organization (WIPO), Cornell University, and the international business school INSEAD. This index assesses the level of innovative development, based on the creative potential and the effectiveness of innovative activities. Innovative potential is measured by the following criteria:

- institutions – political, regulatory and business environment;
- human capital and research – quality of education, development of higher education, research and innovation activities;
- infrastructure – information and communication technologies, general infrastructure and environmental sustainability;
- market environment – access to credit, investment, trade, diversification and market size;
- business environment – the level of knowledge and skills of employees, innovative cooperation and knowledge implementation.

Innovation activity results are assessed according to the following parameters:

- knowledge and technology – creation, dissemination, and impact of knowledge;
- creative results – intangible assets, production of creative goods and services, and online creativity.

Ukraine produces more innovative products than investments (Table 1, Fig. 3).

An analysis of Ukraine's macroeconomic situation suggests that the level of education spending as a percentage of GDP is extremely low after the start of the full-scale invasion (Fig. 4).

To understand the situation, the graph of education spending in some developed countries shows how much Ukraine will need to do in this direction (Fig. 5).

Ukraine spends a significant share of public funds on education, but low efficiency due to a relatively large number of educational institutions and a decrease in the number of students calls into question the effectiveness of using these resources (Fig. 6).

Table 1

Years	Global Innovation Index of Ukraine in 2014–2024		
	Place in the ranking by overall indicator		
	Global Innovation Index	Innovation potential ("input index")	Results of innovation activity ("output index")
2014	63	88	46
2016	56	76	40
2018	43	75	35
2019	47	82	36
2020	45	71	37
2021	49	76	37
2022	57	75	48
2023	55	78	42
2024	60	78	54

Source: compiled by the author based on data from <https://www.wipo.int/en/web/global-innovation-index>.

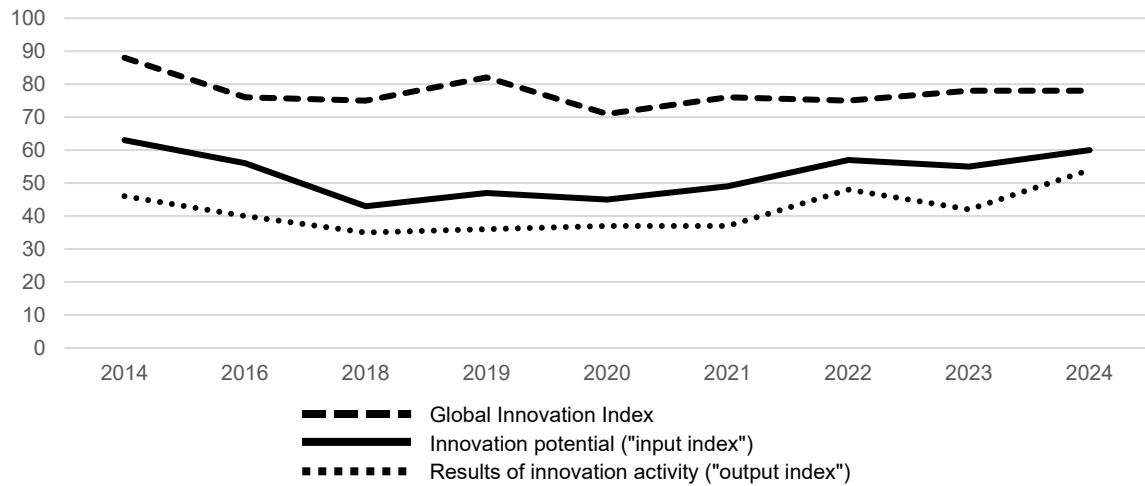


Fig. 3. Global Innovation Index of Ukraine in 2014–2024

Source: built on the basis of WIPO Statistics Database.

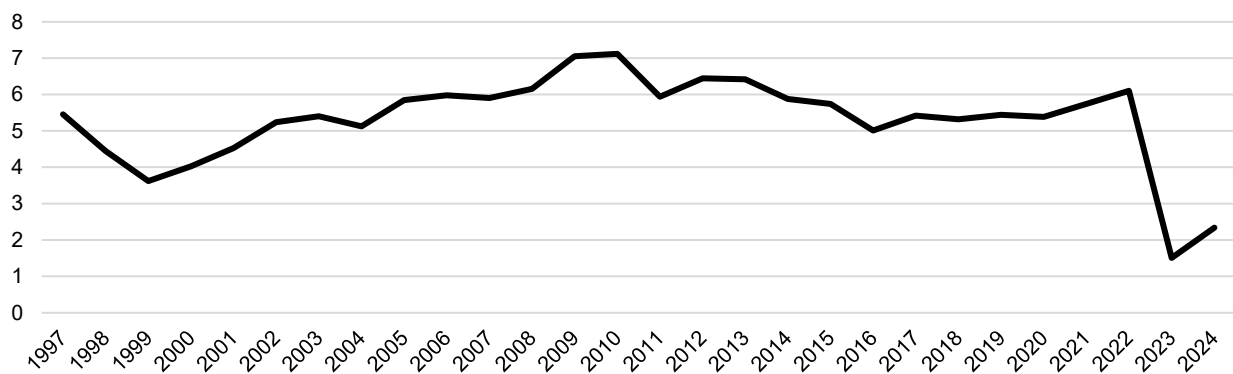


Fig. 4. Education spending in Ukraine, % of GDP, 1997–2023

Source: built by the author based on data from <https://data.worldbank.org>

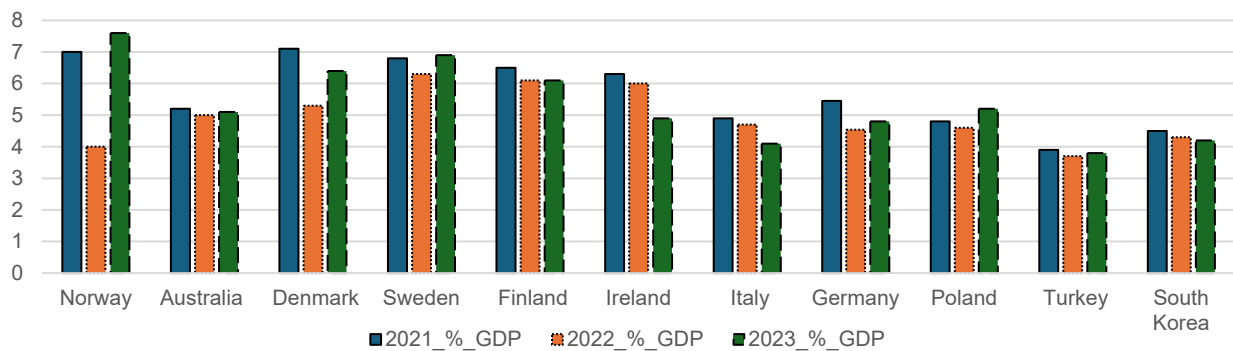


Fig. 5. Total expenditure on education in developed countries of the world during 2021–2023, % of GDP

Source: based on data from <https://stats.oecd.org/>

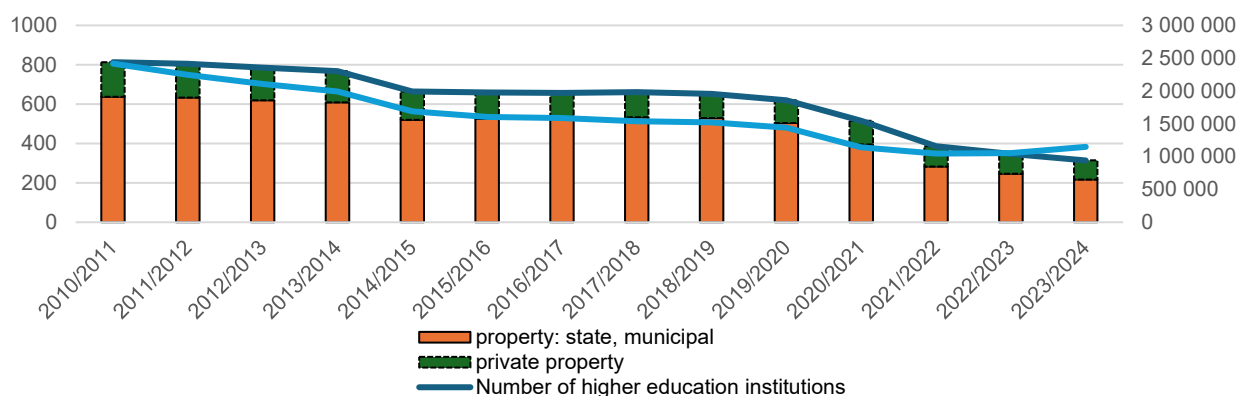


Fig. 6. Number of higher education institutions and number of students for 2010–2024 academic year, units

Source: built based on data from the State Statistics Service of Ukraine and the Ministry of Education and Science of Ukraine.

Ukraine faces extremely complex challenges and can have devastating consequences for the country if certain efforts are not made to eliminate them or, at least, respond to them. This, and macroeconomic vulnerability and fiscal burden, decreases the solvency of the population, which, in turn, limits the possibility of increasing spending on education and requires the most efficient use of available resources to implement reforms in the field of education and attract investment. Therefore, it is worth paying attention to successful examples of financing education and science that could be adapted to domestic realities. One of the most interesting and realistic is the German model of financing education and science, especially the Exzellenzinitiative program ("Excellence Initiative") and its successor – "Exzellenzstrategie" (Deutsche Forschungsgemeinschaft, 2025). Thus, the German government and the states (regions) in 2005 launched a large-scale program to stimulate the development of world-class universities, which provided for holding open competitions among universities for receiving large grants. Those who proposed realistic, ambitious strategies for developing science, innovation, and education received grants (Excellence Strategy of the German federal and state governments, 2025). Funding was competitive, public, and transparent. Top scientists from different countries were involved in the implementation of projects. As a result, Germany received high positions in world rankings in 15 years and attracted thousands of students and scientists worldwide (Federal Ministry of Research, Technology and Space, 2025).

Another interesting example is Israel, which demonstrates the algorithm of actions for creating a "startup nation" (Israel Innovation Authority, 2025). The key steps for implementing the experience are as follows: close integration of science, education and innovative business, commercialization of scientific developments, investment in the "startup nation", education as the basis for development (making higher education as accessible as possible and stimulating the creation of strong technical specialties, focusing universities on solving real needs of the economy and security). The consolidation of universities is underway, which should strengthen their positions in the education market and increase opportunities for obtaining appropriate funding. However, Ukraine is a middle-income country with significant growth potential. Ukraine traditionally benefits from its human capital, particularly its powerful education system and highly qualified labor resources. However, Ukraine has not transformed this human capital into productivity and national wealth. The rapid expansion of the education system has increased the population's education level. Still, its quality and relevance have suffered, with a lack of innovation, isolation, and corruption leading to

dissatisfaction, skills imbalances, and an excessive focus on diplomas. Despite a highly educated workforce, human capital in Ukraine accounts for only 34% of national wealth (compared to the average for Europe and Central Asia of 62%), and labor productivity is only 22% of that in the European Union. This is a sign that the contribution of education to the economy does not match its potential.

Discussion and conclusions

The main goal of higher education in the knowledge economy is to create favorable conditions for the development of human capital and for the production, preservation, dissemination, and use of knowledge. This, in turn, requires ensuring the proper quality of education and adequate financing. Effective financing involves the targeted and transparent use of public funds and the further development of the higher education lending system.

Among the main problems of financing education and science in Ukraine, it should be noted: the lack of innovative financial mechanisms to ensure high quality education and science; the difficulty of attracting credit resources by households due to their high cost; inefficient use of budget funds, due to the lack of clear criteria for socio-economic efficiency and insufficient use of the principle of "evidence-based knowledge transfer"; low level of private investment in science and education due to weak business demand for innovations and insufficient applied orientation of scientific research; a small number of international grants due to weak integration of Ukrainian scientists into the global scientific space.

The situation is further complicated by the transfer of funding for vocational education to local budgets without creating conditions for attracting private investment, in particular through public-private partnership mechanisms, as well as the underdevelopment of public control over the effective use of public resources, taking into account the specifics of the industry.

Public higher education institutions are non-profit organizations. Today, budget funding is mainly limited to covering the basic costs of educational institutions: salaries, scholarships, and payment of utility services. Universities primarily provide material and technical development at the expense of their revenues from paid educational services. Solving the problem of investing in material and technical resources could be a powerful impetus for developing the higher education system as an essential factor in the knowledge economy.

In addition, the volume of public funding for education under state orders almost does not provide for capital expenditures due to limited resources. The current demographic situation, characterized by a decrease in the number of applicants, does not allow for an unreasonable

increase in the cost of training on a contract, including investment costs. This requires optimizing available university resources to allocate funds for investments.

In improving the financing system, it is advisable to focus support on universities with high potential, while simultaneously reducing spending on institutions that do not demonstrate development prospects. It is important to remember that, regardless of the financing model, the priority should remain the renewal of the material and technical base (in particular, laboratories and scientific equipment) and proper remuneration of scientific and pedagogical staff, especially leading scientists. If these conditions are met, world-class universities will appear in Ukraine.

The prospect of further research will be to study existing successful models of financing higher education and their possible implementation in Ukraine and the search for alternative funding sources for higher education.

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ФІНАНСУВАННЯ ВИЩОЇ ОСВІТИ В КОНТЕКСТІ СУЧАСНИХ ВИКЛИКІВ

Вступ. Основним фундаментом якісного розвитку економіки країни є рівень розвитку її освіти та науки. В умовах поточних викликів, це критично важливо для виживання країни. Стан освіти та науки в Україні вкрай залежить від наявних ресурсів для їхнього фінансування, пошуку успішних світових прикладів та їх імплементації та адаптації до сучасних реалій країни, критичність у підходах до обрання критеріїв щодо першочерговості фінансування саме освіти та науки. Метою дослідження є аналіз стану фінансування вищої освіти в Україні, взаємозв'язок з індексом людського розвитку та пошук можливих траєкторій подальшого розвитку досліджуваної сфери.

Методи. Для розкриття мети і завдань дослідження використано методи аналізу і синтезу (узагальнення та виокремлення ключових позицій дослідження); статистичний (опрацювання статистичної інформації щодо поточного стану фінансування вищої освіти), графічний (для наочного відображення досліджуваних процесів).

Результати. Продемонстровано вплив таких результатуючих показників як Індекс людського розвитку (ІЛР) та Глобальний інноваційний індекс на формування пріоритетів державної політики в Україні. Виявлено, що Україна виробляє більше інноваційної продукції порівняно з рівнем інноваційних інвестицій та те, що Україна у рейтингу ІЛР має результати, вищі за прогнозовані. Україна витрачає значну частку державних коштів на освіту, але має низьку ефективність через досить велику кількість освітніх закладів і динаміку зменшення кількості студентів, що ставить під сумнів ефективність використання цих ресурсів. Проаналізовано приклад роботи німецької моделі фінансування освіти й науки, де, через проведення відкритих конкурсів серед університетів на отримання великих грантів стан зазначеної галузі показав стрімкий розвиток, який відображено у рейтингових позиціях університетів, і приклад Ізраїлю, який демонструє алгоритм дій для створення "стартап-нації".

Висновки. Визначено, що розвиток економіки знань вимагає якісної освіти й ефективного фінансування, що передбачає прозоре використання державних коштів і стимулювання кредитування вищої освіти. Основними проблемами є відсутність інноваційних фінансових механізмів, низька інвестиційна активність бізнесу та слабка інтеграція науки у міжнародний простір, що знижує ефективність використання ресурсів. Для досягнення прориву у сфері освіти необхідно інвестувати в матеріально-технічну базу університетів, оптимізувати бюджетні витрати та підтримувати заклади з високим потенціалом розвитку.

Ключові слова: інноваційний розвиток, інвестиції, індекс людського розвитку, інноваційний потенціал, моделі фінансування вищої освіти.

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QUANTIFYING THE INTERNATIONALIZATION CAPACITY OF SMALL AND MEDIUM-SIZED ENTERPRISES

Background. *The article examines the problem of involvement of Ukrainian small and medium-sized businesses in foreign economic activity (FEA) in the context of deep structural changes caused by martial law, the transformation of the global economy, and digitalization. The relevance of the topic is driven by the need to formulate an effective policy to support small and medium-sized businesses to boost exports, imports, and integration into international markets, which are critical to the country's economic recovery. The purpose of the study is to quantify the export capacity, import activity, and overall involvement of enterprises of different sizes in FEA, as well as to identify barriers and formulate measures to enhance the internationalization of small and medium-sized businesses.*

Methods. *The methods of statistical analysis, comparative approach, normalization of indicators (min-max method), and construction of integral indices are used in the study. An empirical analysis of the statistical data of the State Statistics Service of Ukraine for 2016–2023 is carried out.*

Results. *The results show that micro and small enterprises have increased the efficiency of export and import activities, especially under martial law, while large enterprises have lost momentum. The indices of export capacity, import activity, and overall involvement in FEA were constructed, which allowed us to establish the leadership of medium-sized enterprises in terms of export capacity in 2023 and the growth of import intensity of microenterprises. Barriers related to lack of funding, certification difficulties, and low digital readiness have been identified.*

Conclusions. *The practical value of the study lies in the proposed tools for assessing the participation of small and medium-sized businesses in FEA and recommendations for supporting their internationalization.*

Keywords: *small and medium-sized business, foreign economic activity, export capacity, import activity, involvement in foreign economic activity, digitalization, e-commerce, barriers to foreign economic activity.*

Background

The introduction of martial law has led to structural changes in the national economy and forced the country to adapt its economic mechanisms to new conditions, as the destruction of production facilities, loss of qualified personnel due to forced migration and a sharp decline in demand in the domestic market make it more important than ever to ensure economic stability, which is becoming a significant challenge for the government and the business environment (Ministry of Economy of Ukraine, 2024). Such global challenges are driving transformation processes aimed at finding alternative ways of development and adaptation to new conditions, including access to international markets and active use of digital technologies.

Despite these challenges, a significant number of SMEs have managed to adapt; some have rebuilt their business models, while others have integrated into the wartime economy and supported humanitarian initiatives. At the same time, there is still the issue of finding opportunities to build new strategies for development and survival. In such circumstances, an international market entry strategy becomes an important tool for ensuring business sustainability.

Given the transformation of global trade relations, the digitalization of the economy, and the growing importance of production chain sustainability, it is of particular importance to increase the participation of small and medium-sized businesses (SMEs) in FEA. Despite their flexibility, innovation, and adaptability, SMEs often face many barriers to entering international markets. At the same time, the level of SME involvement in exports, imports, and international cooperation is largely determined not only by external

factors but also by the internal ability of enterprises to implement their foreign economic strategy.

The purpose of the study is to quantify the export capacity, import activity, and overall involvement of enterprises of different sizes in FEA, as well as to identify barriers and formulate measures to enhance the internationalization of small and medium-sized businesses. The object of this research is the FEA of Ukrainian enterprises, categorized by size. The subject of the research is the structural and dynamic variations in FEA across enterprise sizes, including the effects of digitalization and systemic barriers on the development of targeted policy recommendations. The research objective leads to the formulation of the following hypotheses.

H1: The participation of Ukrainian SMEs in FEA varies significantly across enterprise size categories, with firms of different scales demonstrating distinct levels of export potential, import intensity, and overall engagement in international trade.

H2: Policy measures aimed at enhancing the export potential, import activity, and overall internationalization capacity of SMEs should be differentiated according to enterprise size, activity level, and the specific structural and institutional barriers constraining their development.

The scientific novelty of the study lies in the proposed methodology for assessing the level of involvement of enterprises of different sizes in foreign trade and systematizing the barriers and opportunities for these enterprises to carry out such activities.

Literature review. SMEs are the backbone of Ukraine's economy, accounting for 99.98 percent of all business entities, providing 74 percent of all jobs, and generating

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64 percent of added value (United Nations Development Programme in Ukraine, 2024).

It is noted that 40 percent of companies consider export development as a strategy to overcome the crisis under martial law (CID.CENTER, 2022). Integration into global value chains allows for expanding the market, increasing openness, and taking advantage of knowledge sharing and efficiency gains (E.Verhoogen, 2023). Thus, internationalization gives SMEs a chance not only to survive under martial law but also to expand their capabilities, adapt their business to global standards, and create a solid foundation for post-war economic recovery.

The relevance of assessing SMEs' ability to engage in foreign trade is driven by the need to develop an effective state policy to support export and import activities, particularly in the context of Ukraine's integration into the European market and post-war recovery. A comprehensive assessment of the ability of enterprises of various sizes (micro, small, medium) to conduct FEA, as well as the identification of key barriers and growth points, is a prerequisite for the development of sound recommendations for strengthening the international competitiveness of SMEs.

According to the bibliometric analysis of 195 scientific sources from the Scopus database by R. Chopra et al. (2024), the key factors of SMEs' ability to participate in foreign trade are managerial resources, innovation capacity, access to market information, and digital competencies. The study also outlines typical barriers to SME internationalization, including information, financial, institutional, and cultural constraints, which coincide with the findings of our analysis. SME internationalization is defined as a strategic process of enterprises entering foreign markets, which includes not only exports but also the expansion of partnership networks, product adaptation, and digital transformation.

A survey of 110 enterprises conducted by AKM Asaduzzaman Patwary et al. (2024) showed that the export capacity of SMEs is closely related to the structural characteristics of the enterprise: size (number of employees), experience (length of service), and market type, and is significantly limited by financial and institutional barriers. The constraints identified in this study are similar to those identified for Ukrainian SMEs: lack of information, complexity of certification, and lack of government support.

The study by Sulhan and Sudarmiatin (2022) showed that with a combination of high product quality, active digital promotion, and local association support, SMEs can implement an aggressive strategy of expanding into international markets even in the face of external risks. The authors emphasize the synergy of a quality product, digital presence, and institutional cooperation, which allows SMEs to implement a proactive internationalization strategy, even in a highly volatile environment.

According to Sudarmiatin et al. (2024), SME internationalization requires a comprehensive approach, namely a combination of internal motivation and adaptation to external conditions, such as access to finance, government support, and cooperation development. The barriers identified in this study – lack of coordination, regulatory complexities, and weak institutional support – reflect universal problems of SMEs, including those in Ukraine. The proposed "government-business-universities (+society)" model of internationalization emphasizes the importance of synergies between business, government, and the educational environment.

According to Ratten (2023a), digital platforms have become a key tool for the internationalization of SMEs. The author emphasizes that internationalization in the digital era

no longer requires a step-by-step build-up of experience but can be realized through inclusion in digital ecosystems. This opens new opportunities but also increases the dependence of SMEs on the level of innovation and digital skills. Digital platforms such as Amazon, Alibaba, or Etsy act as a driver of internationalization and significantly reduce barriers to entry for SMEs in global markets. They are turning internationalization into a digital transformation. This enables new types of entrepreneurship in digital ecosystems, namely, instead of the traditional search for markets, they are embedded in existing global networks. SMEs get access to market information, logistics, and cross-border payments without intermediaries.

Denicolai, Zucchella, and Magnani (2021) investigated the interaction between three growth paths of SMEs: internationalization, digitalization, and sustainable development. The results of an empirical study of 438 enterprises showed that readiness for artificial intelligence has a positive impact on the international activities of SMEs. Among other things, the authors found that digitalization and sustainability are positively related, but they become competing growth paths when a firm enters the international market. According to the authors, a new scenario is emerging where sustainable development is increasingly becoming a "meta-driver" that can strengthen other growth paths, such as digitalization or internationalization.

According to Lobo et al. (2020), the international market entry of SMEs depends on a number of factors, including cultural differences, company traditions, venture capital, transaction costs, resources and capabilities, products, and competitors. The authors also note that the evolution of information and communication technologies has given SMEs access to customers, suppliers, and employees around the world. The study identified the following as control variables for determining activity in foreign trade: economic activity, company age, size (number of employees), and the share of company turnover from internationalization. The authors consider the decision of SMEs to enter the international market as a tool in response to external pressure within their own country.

Gron and Sikalenko (2021) analyzed the methods and indicators for assessing the level of export potential of an enterprise. The researchers proposed to determine the export potential in production, finance, human resources, export opportunities, competitiveness of export products, and participation in international industrial cooperation. For each area, the express assessment identifies indicators that allow for determining the export capabilities of an enterprise. The proposed methodology reveals more about the content of the effectiveness of the enterprise's export activity, although it may indirectly indicate the enterprise's ability to carry out such activities.

According to Blyzniuk (2023), Ukrainian enterprises should focus on foreign markets to survive. The author identifies the insufficient number of solvent customers in the domestic market as the main problem on the way to business recovery and development. Therefore, one of the ways to overcome this problem is to develop exports. Digitalization processes provide SMEs with important support tools: analytics of foreign markets, educational events, consulting, tools for finding foreign partners, grants from the state and donor organizations (Blyzniuk, 2023).

Analysis across OECD countries (Sakiru, Gil-Alana, & Gonzalez-Blanch, 2022) shows that improving framework conditions, such as enhancing the rule of law, reducing regulatory burdens, providing adequate physical infrastructure, and supporting innovation, contribute to

economic sophistication and make it easier for companies to enter the international market.

An important factor that has a significant impact on the process of entering the international market for SMEs is digitalization, which plays a fundamental role. The continuous development of information and communication technologies has greatly expanded the opportunities for cross-border e-commerce, which has become a new, effective way to enter the international market (Cassia, & Magno, 2022).

Gamova (2023) argues that e-commerce has become an essential component of the global trading system and a catalyst for globalization. It constitutes one of the principal factors influencing the growth of average national income (GDP per capita) and long-term macroeconomic productivity, thereby reinforcing global interdependencies among economies. The author further notes that the Ukrainian e-commerce market is projected to grow at an annual rate of 9% between 2021 and 2025, surpassing the global average of 6%. For SMEs seeking to expand internationally, Gamova identifies several systemic and market-related risks, including global crises, deceleration of global economic growth, logistical and infrastructural constraints, market saturation, competition, domestic market orientation, and uneven globalization.

Vergeles and Bayura (2024) contend that, in conditions of economic instability, SMEs can enter international markets only through organizational transformation, with digitalization serving as a pivotal mechanism for accelerating market expansion and developing new income streams. Nevertheless, macroeconomic and geopolitical instability in Ukraine, coupled with internal challenges such as cybersecurity vulnerabilities and shortages of skilled personnel and digital expertise, continue to present significant barriers to effective business internationalization.

Thus, the need for SMEs to enter the international market is driven by several reasons: survival under martial law conditions (loss of resources, markets, logistics); search for stable sources of income and foreign exchange earnings; increasing sustainability through market diversification; increasing competitiveness and implementing European standards; the opportunity to become part of global value chains (GVCs); increasing economic complexity and business innovation.

The literature review identified the following barriers to SME exports, imports, and FEA: infrastructural (loss of production capacities, logistics disruptions (blockade of ports, transportation restrictions)); financial (high rates, instability of the banking system, lack of access to grants); human resources (outflow of specialists, lack of knowledge in foreign trade, language barriers) institutional (inspections, fragmented support, lack of coordinated policy); communication (lack of partners in the EU, distrust of SMEs from Ukraine, poor awareness); certification and standards (high cost of compliance with EU standards, and complexity of procedures).

It should be borne in mind that enterprises of different sizes demonstrate different capacities for importing, exporting, foreign trade, digitalization, e-commerce, and adaptation to modern sales channels. Thus, taking into account these features allows us to identify barriers and areas for intensifying foreign trade. For Ukraine, this is important for active integration into the global economy, as well as for the formation of new approaches to the participation of enterprises in global markets.

Methods

Empirical analysis and the method of theoretical generalization of scientific literature were used to determine

the views of scientists on the essence and tools for assessing the level of readiness of enterprises to engage in FEA. Summarizing theoretical approaches, the study focused on building methodological tools for assessing the export, import, and overall ability of SMEs to participate in foreign trade.

Comparative statistical analysis was used to compare the trends in FEA for enterprises with different numbers of employees, as one of the basic criteria for dividing enterprises by size, as provided by law (On Accounting and Financial Reporting in Ukraine, 1999: Law of Ukraine; Commercial Code of Ukraine: Law of Ukraine): micro – up to 10 people; small – up to 50; medium – up to 250; large – over 250.

Methods of statistical data analysis were used to identify trends in the involvement of SMEs in foreign trade in 2016–2023. In particular, attention was paid to the study of trends in the activity of enterprises with different numbers of employees in the implementation of FEA by the following indicators: percentage share of exports in total section; sales of imports in total section sales; exports per each employed worker in thousand USD; imports per each employed worker, in thousand USD; exports per 1 UAH of personnel costs; imports per 1 UAH of personnel costs; volume of products sold per each employed worker, UAH thousand; and volume of products (goods, services) sold by enterprises received from e-commerce as a percentage of the total volume. This made it possible to determine which types of enterprises, in terms of the number of employees, demonstrate higher involvement in foreign trade to compare the results with the policy of supporting foreign trade and SMEs, and to formulate the main obstacles that arise in the course of such activities.

A review of the methods used in world practice to assess the readiness of enterprises for foreign trade and the efficiency of foreign trade, and the results of statistical analysis of the export and import activity of SMEs, allowed us to propose a methodological approach to determining the export capacity, import activity, and overall participation in foreign trade for enterprises with different numbers of employees. This was done by combining economic and statistical analysis with analytics of FEA and using an index approach with preliminary normalization of variables using the min-max method. The following indicators were used for the export capacity index: percent of the share of exports in the total sales of the section; exports per employed worker, in thousand USD; exports per 1 UAH of personnel costs; volume of products sold per employee in thousand UAH. The following indicators were used for the import activity index: percent share of imports in total section sales; imports per one employed worker, in thousand USD; imports per UAH 1 of personnel costs; volume of products sold per employed worker in UAH thousand. The following indicators were used for the index of total participation in FEA: percent share of exports in the total sales of the section; share of imports in the total sales of the section; exports per each employed worker, as thousand USD; imports per each employed worker, as thousand USD; exports per 1 UAH of personnel costs as UAH; imports per 1 UAH of personnel costs; volume of products sold per each employed worker, as thousand UAH; volume of products (goods, services) sold by enterprises received from e-commerce as a percentage of the total volume. The purpose of this assessment was to determine the level of involvement of SMEs in foreign trade, as well as to consider the impact of export and import and SME support policies in Ukraine. This made it possible to build a systematic list of barriers that hinder the participation of SMEs in foreign trade and to outline the main measures to intensify this activity.

The main data sources were official reports of the State Statistics Service of Ukraine, which provided information on the performance of SMEs.

Graphical methods were used to illustrate theoretical and practical materials.

Results

Since 2016, the policy of state support for exports, imports, and foreign trade of SMEs in Ukraine has gone through a number of successive stages reflecting the evolution from a declarative strategy to systemic digital integration.

On January 1, 2016, the Association Agreement and DCFTA (Deep and Comprehensive Free Trade Area) between Ukraine and the EU entered into force, aimed at harmonizing tariffs, sanitary and technical standards (Bala, & Ivantsyk, 2024). At the initial stage (2016–2017), the strategic framework for SME support was laid by adopting the Export Strategy of Ukraine (the so-called Roadmap for 2017–2021), which, for the first time, focused on the needs of small businesses in international trade. During this period, policy priorities were mainly formulated without a developed infrastructure for their practical implementation.

In 2018–2019, the policy was institutionalized. The Export Promotion Office of Ukraine was established, export clusters were formed, and training programs were introduced in cooperation with international organizations (EBRD (European Bank for Reconstruction and Development), GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), CUTIS (Canada-Ukraine Trade and Investment Support Project), etc.) The first examples of SME participation in

business-to-business (B2B) forums, trade missions, and advisory initiatives have emerged.

In response to the COVID-19 pandemic (2020–2021), support policies were rapidly adapted to digital formats. Online platforms, including a single export web portal, were introduced, and virtual exhibitions, trade meetings, and webinars were made available. This stage is characterized by SMEs turning to e-commerce and digital marketing as an alternative to traditional export channels.

After the start of the full-scale Russian invasion (starting in 2022), the government focused its efforts on anti-crisis and relocation support for SMEs' export potential. The Relocate for Export program was launched, logistics and certification costs were compensated, and international assistance was intensified. The Diia.Business (Ministry of Digital Transformation of Ukraine, n. d.-b), UkraineNow (Ministry of Culture and Strategic Communications of Ukraine, n. d.), and Export Recovery Platform platforms have become key channels of communication and mobilization of SMEs for foreign trade in difficult security conditions.

Since 2024, there has been a gradual transition to an integrated, digitally-oriented export policy, which involves unifying access to finance, knowledge, logistics, and promotion within a single digital ecosystem. It is expected to expand the functionality of export platforms, introduce ESG approaches to foreign trade, and strengthen the participation of SMEs in global value chains (GVCs).

Figure 1 shows the growth rate of output per employed worker at enterprises of different sizes (classified according to Ukrainian legislation in Table 1) compared to 2016.

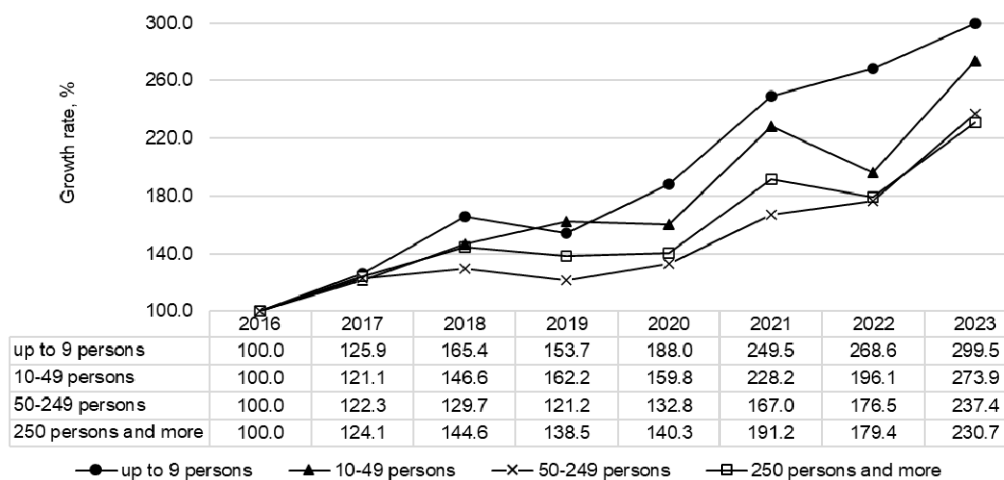


Fig. 1. Growth rate of output per employed worker by number of employees in % compared to 2016

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

The analysis showed that from 2016–2023, all categories of enterprises showed an increase in this indicator, but especially micro and small enterprises. Since 2016, micro and small enterprises have been outpacing large ones in terms of sales per employee. During the analyzed period, the volume of output per 1 employed worker increased almost 3 times for micro enterprises, 2.7 times for small enterprises, 2.4 times for medium-sized enterprises, and 2.3 times for large enterprises. This indicates a marked increase in labor efficiency in SMEs, especially among micro and small enterprises, which demonstrate flexibility and adapt to changes more quickly.

Figure 2 shows the volume of output per each employed worker as a percentage of the same indicator for microenterprises.

Since 2016, the gap between the volume of output per each employed worker of large, medium, small, and micro-enterprises has been widening. While in 2016 this indicator for large enterprises was at the same level as the same indicator for microenterprises, in 2023 it was already 76.6 percent. In 2023, the highest values of this indicator were at micro and small enterprises, respectively, UAH 3046.5 and 3058.3 thousand. This indicates that the transformations taking place in the economy are reducing the benefits and mitigating the barriers to doing business for enterprises of different sizes.

Figures 3, 4 show the shares of exports and imports as a percentage of total exports and imports of enterprises of different sizes, respectively.

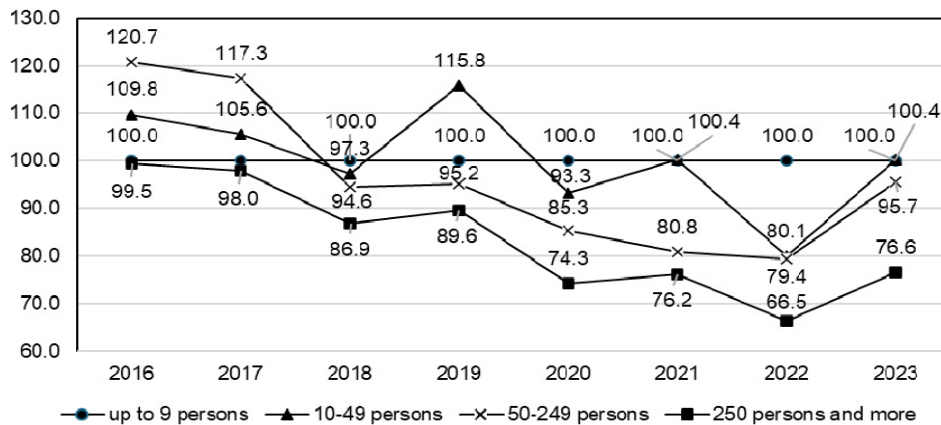


Fig. 2. Output per employed worker in enterprises of different sizes as a percentage of the same indicator for microenterprises

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

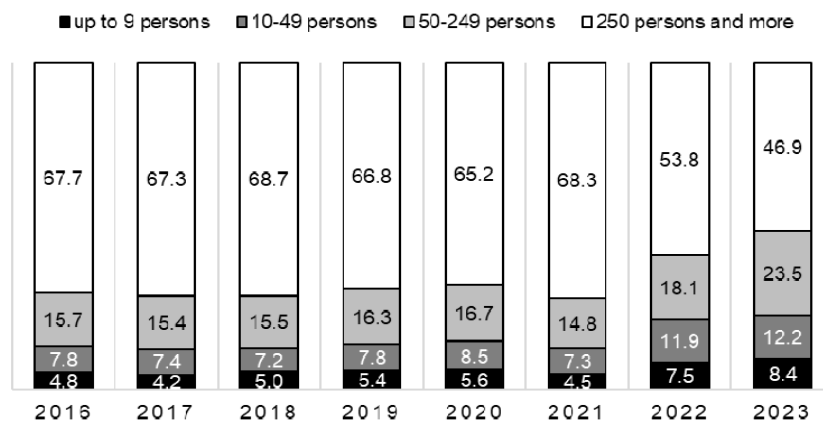


Fig. 3. Share of exports as a percentage of total exports by number of employees

Source: compiled by the authors based on data from the State Statistics Service of Ukraine (2024): exports of goods by economic entities by number of hired workers by types of economic activity in 2016–2023.

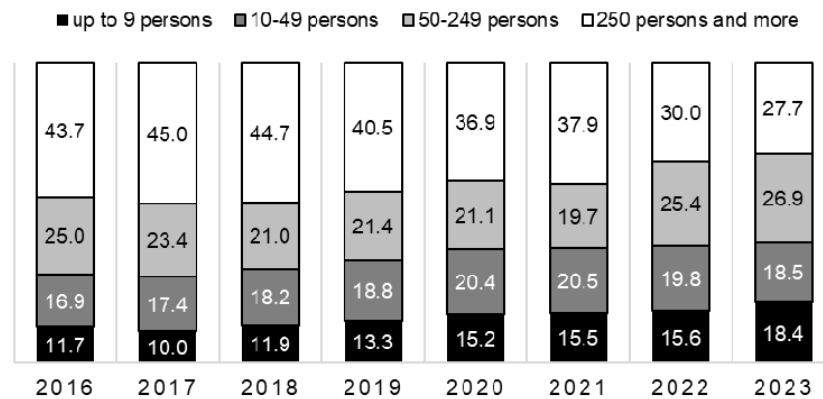


Fig. 4. Share of imports in percent of total imports by enterprises by number of employees

Source: compiled by the authors based on data from the State Statistics Service of Ukraine (2024): import of goods by economic entities by number of hired workers and by types of economic activity in 2016–2023.

The share of exports of large enterprises as a percentage of total exports of enterprises is steadily declining: from 67.7 percent (2016) to 46.9 percent (2023). Meanwhile, SMEs are increasing their export activity, but with different intensity. Thus, the share of exports by microenterprises increased from 4.8 percent to 8.4 percent over the study period; by small enterprises, from 7.8 percent to 12.2 percent; and by medium-sized enterprises, from 15.7 percent to 23.5 percent. Medium-sized enterprises showed a particularly significant increase in 2022–2023.

Also, during the study period, there was a sharp drop in the share of imports by large enterprises: from 43.7 percent (2016) to 27.7 percent (2023). Small enterprises consistently hold between 16.9 percent and 18.5 percent of the market. In 2023, medium-sized enterprises became the leaders among SMEs in terms of imports (26.9 percent), but their share increased by only 1.9 percentage points over the study period. The share of microenterprise imports in total enterprise imports showed the largest increase from 11.7 percent in 2016 to 18.4 percent in 2023.

Thus, there is a gradual decrease in the monopoly of large enterprises on exports. Medium-sized businesses are becoming active participants in foreign trade, while micro and small enterprises are beginning to strengthen their positions.

In 2022–2023, the share of exports by medium and micro enterprises increased, while the share of imports increased only by micro enterprises. This is partly because from June 29, 2022, to June 5, 2025, Ukraine and the European Union signed an agreement on duty-free transportation to the EU ("permit-free" roads). The agreement cancels the requirement for Ukrainian carriers to obtain appropriate permits for bilateral and transit transportation to the EU and avoids stopping the export of Ukrainian products through road checkpoints (logist.fm, 2025). In view of this, the requirements for SMEs to enter international markets have been eased.

Among other things, imports are becoming more diversified, and large companies are losing share to medium-sized enterprises. This indicates a greater involvement of SMEs in global supply chains.

Under the auspices of the United Nations, a survey was conducted to identify threats and limitations to the impact of the conditions under martial law on micro, small, and medium-sized enterprises in Ukraine (United Nations Development Program in Ukraine, 2024). percent do not carry out FEA at all, 10.9 percent carry out only export operations, 13.1 percent carry out only import operations, 10.8 percent carry out export-import operations, and 8.0 percent plan to enter the international market in 2024.

Figures 5, 6 show, respectively, exports and imports for each employed worker for enterprises of different sizes.

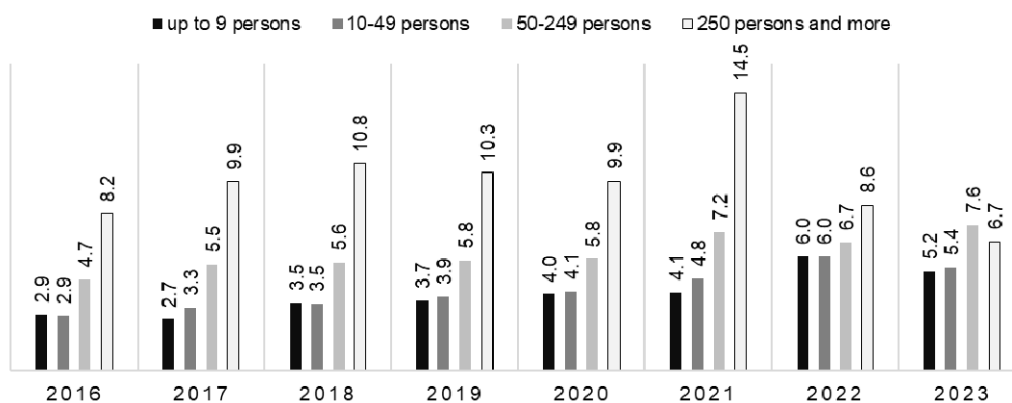


Fig. 5. Exports per each employed worker of enterprises of different sizes, thousand USD

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): exports of goods by economic entities, by number of hired workers and by types of economic activity in 2016–2023; State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

The largest value of exports per each employed worker was observed at large enterprises, followed by medium-sized enterprises, and with a small margin, almost the same value at small and micro enterprises. In general, in 2016–2023, exports per each employed worker at microenterprises increased by 1.8 times, at small enterprises by 1.9 times, and at medium-sized enterprises by 1.6 times. At large enterprises, exports per employee in 2023 amounted to

82 percent of the level of 2016. Micro- and small enterprises saw a gradual increase in exports per employee from 2016 to 2021, with a sharp jump in 2022 (likely due to staff reductions while exports remained stable). Large enterprises, after peaking in 2021 (USD 14.5 thousand), experienced a sharp drop in 2022–2023 to USD 6.7 thousand, i.e., by 53.8 percent in 2 years. Medium-sized enterprises in 2023 have the highest figure (\$7.6 thousand) among all groups.

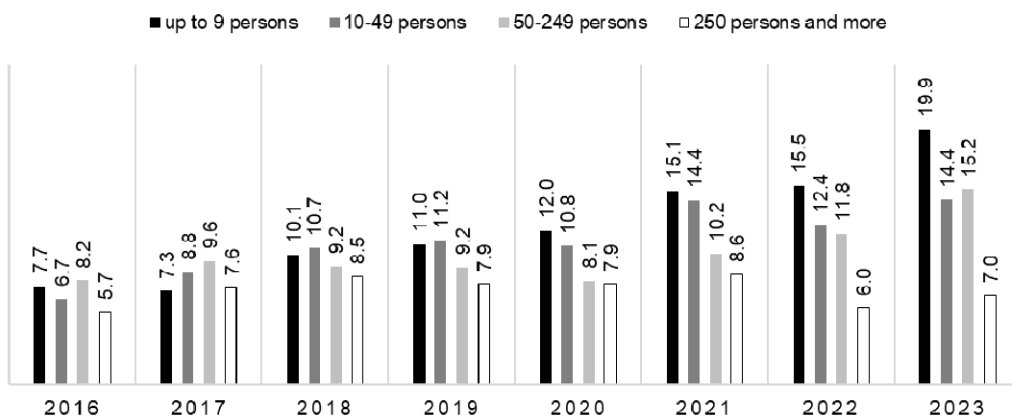


Fig. 6. Imports per each employed worker of enterprises of different sizes, thousand USD

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): import of goods by economic entities, by number of hired workers and by types of economic activity in 2016–2023; State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

The highest value of imports per employee was observed in microenterprises, followed by SMEs, and in last

place, large enterprises. In particular, in 2023, imports per employee at large enterprises amounted to 35 percent of the

level of microenterprises and about 45–48 percent of the level of SMEs.

The largest increase in imports per employee is demonstrated by microenterprises: from 7.7 to 19.9 thousand USD, which means a 2.6-fold increase over 2016–2023, the highest intensity among all groups. Medium-sized enterprises have also stepped up their imports: from 8.2 to 15.2 thousand USD, which is a 1.9-fold increase over seven years. Large enterprises have hardly changed their import intensity, and it even fell from 8.6 thousand USD per

employee in 2021 to 7.0 USD in 2023. Overall, large enterprises increased their import intensity by 20 percent in 2016–2023.

Figures 7–8 show, respectively, the exports and imports of personnel costs by the number of employees. Exports per UAH of personnel costs show the efficiency of exports relative to personnel costs. Imports per UAH of personnel costs show the intensity of import activity relative to personnel costs.

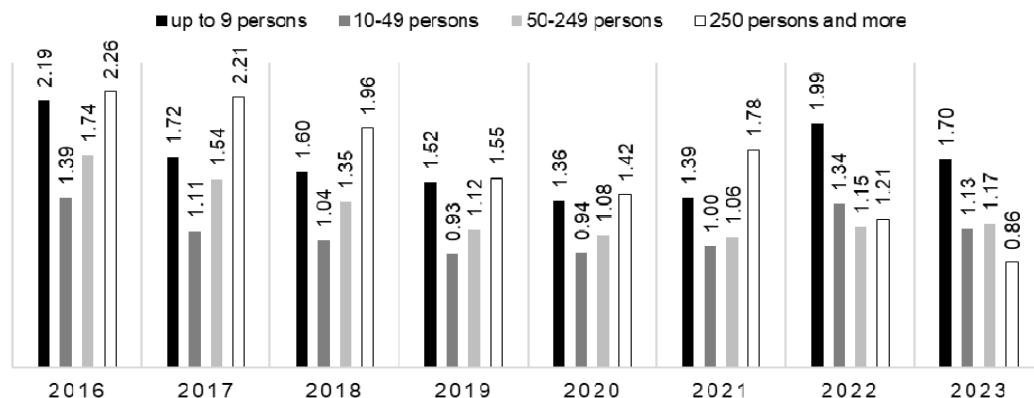


Fig. 7. Exports per UAH of personnel costs by number of employees, UAH

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): exports of goods by economic entities, by number of hired workers, and by types of economic activity from 2016 through 2023; State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

In microenterprises, exports per UAH of personnel costs decrease until 2020, then recover to a peak of 1.99 (2022), followed by a decline to 1.70 in 2023. At large enterprises, after a long leadership in 2016–2022, there is a sharp drop in 2023 to UAH 0.86. This is the lowest value for the entire period. Small firms have the lowest values in almost all

years, although there is a slight increase in 2022–2023, which can be explained by the agreement on preferential treatment of exports to the EU. This suggests that small enterprises need support to increase their export efficiency. Medium-sized enterprises show a gradual decline in 2016–2022, with stabilization in 2023 at UAH 1.17.

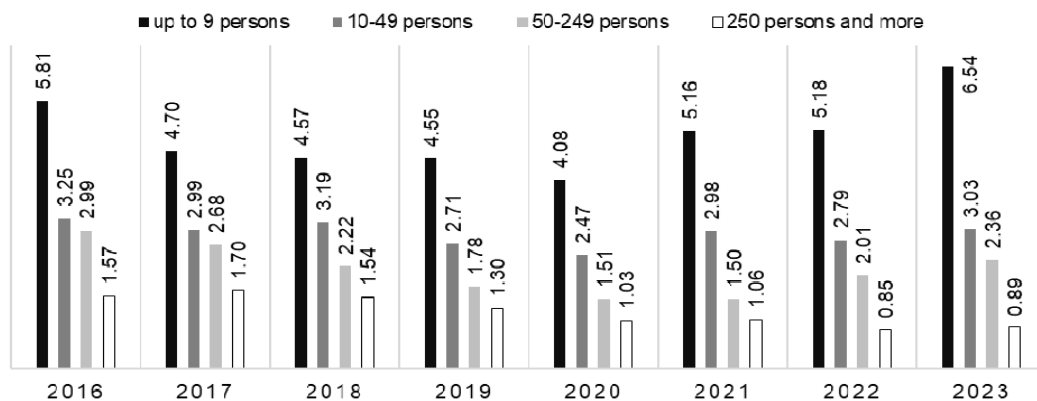


Fig. 8. Imports per UAH of personnel costs by number of employees

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): import of goods by economic entities, by number of hired workers, and by types of economic activity from 2016–2023; State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023.

Microenterprises consistently have the highest import intensity, especially in 2023 – UAH 6.54 of imports per UAH of personnel costs. Only microenterprises showed positive dynamics of imports per UAH of personnel costs in 2016–2023, by 12.7 percent.

Large enterprises have the lowest import intensity, and the indicator is falling: from 1.57 (2016) to 0.89 (2023), i.e., it is almost halved. In 2023, imports per UAH of personnel costs at large enterprises amounted to 13.6 percent of the level of the same indicator for microenterprises.

Medium-sized enterprises show a gradual decrease in imports per UAH of personnel costs until 2021, and then an increase. Overall, there was a 20 percent decrease over the study period. In 2023, the import efficiency of personnel costs at medium-sized enterprises was 36.1 percent of the level of the same indicator for microenterprises.

For small enterprises, imports per UAH of personnel costs ranged from 2.47 to 3.25 without a pronounced trend. During the study period, its value for small enterprises

ranged from 46 to 70 percent of the level of the same indicator for microenterprises.

Table 1 compares the efficiency of personnel costs for export and import activities for enterprises of different sizes.

Thus, micro and small enterprises are the most "dependent" on imports, if we count per UAH of personnel

costs. Medium-sized enterprises also demonstrate this dependence, but not as high as for microenterprises. Large enterprises are the least import-dependent by this criterion, especially after 2020.

Table 1

Comparison of the efficiency of personnel costs for export and import activities of enterprises of different sizes

Indicator	Average value for the period	Category of enterprises			
		Micro	Small	Medium	Large
Exports/1 UAH of personnel costs, UAH	2016–2021	1.63	1.07	1.32	1.86
	2022–2023	1.85	1.24	1.16	1.04
Imports/1 UAH of personnel costs, UAH	2016–2021	4.81	2.93	2.11	1.37
	2022–2023	5.86	2.91	2.19	0.87
The ratio of imports to exports	2016–2021	2.95	2.75	1.61	0.73
	2022–2023	3.17	2.35	1.89	0.84

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): exports of goods by economic entities, by number of hired workers, and by types of economic activity from 2016 through 2023. State Statistics Service of Ukraine (2024): import of goods by economic entities by number of hired workers by types of economic activity from 2016 through 2023.

SMEs' focus on imports, and large enterprises' focus on exports, is due to several economic, organizational, structural, and institutional factors.

First, micro and small enterprises often operate in the wholesale and retail trade sector, where imports of goods are the basis of their business. Most of the imports in this segment are finished goods (clothing, household appliances, cosmetics, tools, etc.), which they resell.

Second, due to a lack of investment and small scale, microenterprises do not tend to produce sophisticated products that could enter international markets.

Third, low institutional support for exports does not allow them to overcome barriers related to logistics, certification, language, and cultural restrictions. Import activities have fewer regulatory requirements and require less initial investment.

Fourth, imports take advantage of price flexibility. SMEs often look for cheaper purchases abroad (in particular, in China, Turkey, and Poland), which allows them to make quick profits in the domestic market.

Fifth, the absence of their own brand or unique products does not allow SMEs to compete in the international market.

Large enterprises in Ukraine (agriculture, metallurgy, chemicals, and mechanical engineering) create products that are competitive on global markets. They have specialists in logistics, certification, international law, their own infrastructure, and contracts with traders. They may have FEA departments, legal departments, and marketing departments that work with foreign customers. Large enterprises can adapt their products to the requirements of foreign markets, undergo international certification, and obtain international standards (ISO, HACCP, etc.). They are the main beneficiaries of state support programs, preferential lending, access to the EBRD (European Bank for Reconstruction and Development), the ECA (Export Credit Agency), and participation in exhibitions. Large production volumes help to reduce costs and be competitive in the global market.

Given this, SMEs are mainly "consumers" of global trade, while large companies are "suppliers" to foreign markets. This situation is typical for economies with unevenly developed business environments and requires government support for the export transformation of small businesses.

In the pre-digital era, it was mostly large and medium-sized companies that entered the international market. This is because this process requires certain financial, human, and managerial resources. In addition, this activity is

associated with a higher level of risk compared to activities in the local market. In most cases, small and micro enterprises simply do not have enough resources for this. However, in the process of digital transformation and globalization, tools and methods are emerging that are becoming available to small and medium-sized businesses.

Digital transformation processes have led to the rapid development of online commerce. This, in turn, was made possible by the corresponding development of the logistics infrastructure. These processes were followed by the development of such an e-commerce segment as marketplaces (Dicuonzo et al., 2022; Ratten, 2023b). Amazon, AliExpress, eBay, Etsy, and Rozetka – all these resources allow small and micro enterprises to organize online sales quickly and without excessive costs. Among these marketplaces, Amazon, eBay, and Etsy are worth highlighting as those that allow mastering of selling abroad through e-commerce. Each of them has its own characteristics, which make them more or less suitable for businesses depending on the type of activity they are engaged in or the type of products they offer. In 2018, Ukraine was among the top nine countries with more than 10,000 sellers on Amazon, and in 2024, the number exceeded 20,000 (NewsLetter Forbes Ukraine, 2025). As of 2024, there were 7.5 million active sellers on the marketplace, including more than 50 thousand Ukrainians and 95.1 million active buyers (NewsLetter Forbes Ukraine, 2025). This resource has high potential for small and micro enterprises from Ukraine. However, to succeed, they must, in turn, create a product suitable for remote sales abroad.

Figure 9 shows the volume of products (goods, services) sold per enterprise, obtained from e-commerce.

The volume of products sold from e-commerce grew rapidly in 2018–2023, with the exception of 2022, which saw a drop due to martial law. Overall, the volume sold grew by 2.4 times over the period. In 2018–2021, the growth was 188 percent, or an average of 30 percent annually. In 2023, there was a 1.8-fold jump in this indicator compared to 2022. The development of digital infrastructure, the growth of digital literacy, and the search for opportunities for enterprises to operate in the context of the dangerous existence of an offline business format due to military operations played a role here. However, the share of the volume of products (goods and services) sold from e-commerce in the total volume of products (goods, services) sold by enterprises by type of sales is low and amounted to 4–5 percent in 2020–2023.

The conditions of martial law have accelerated the digitalization of society and the use of digital e-government platforms Diia (Ministry of Digital Transformation of Ukraine, n. d.-a), Diia.Business (Ministry of Digital Transformation of Ukraine, n. d.-b), and Vzaemo.Diia (Ministry of Digital

Transformation of Ukraine, n. d.-c), which has allowed SMEs to use digital tools (OECD, 2024). Figure 10 shows the dynamics of the volume of products (goods, services) sold by enterprises received from e-commerce as a percentage of the total volume of products (goods, services) sold by enterprises.

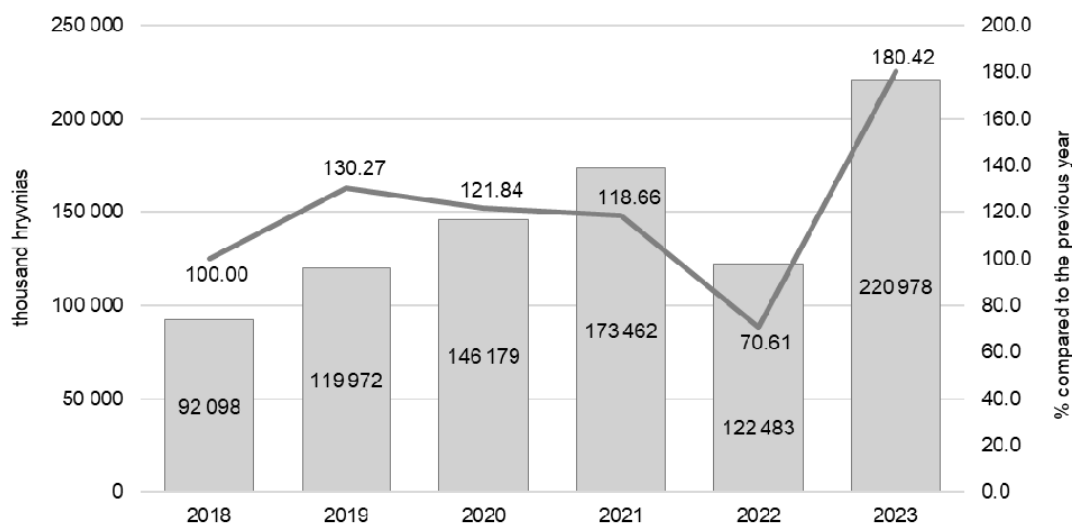


Fig. 9. The volume of products (goods, services) sold from e-commerce per enterprise

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (2024): use of information and communication technologies at enterprises: e-commerce, invoicing 2018–2023.

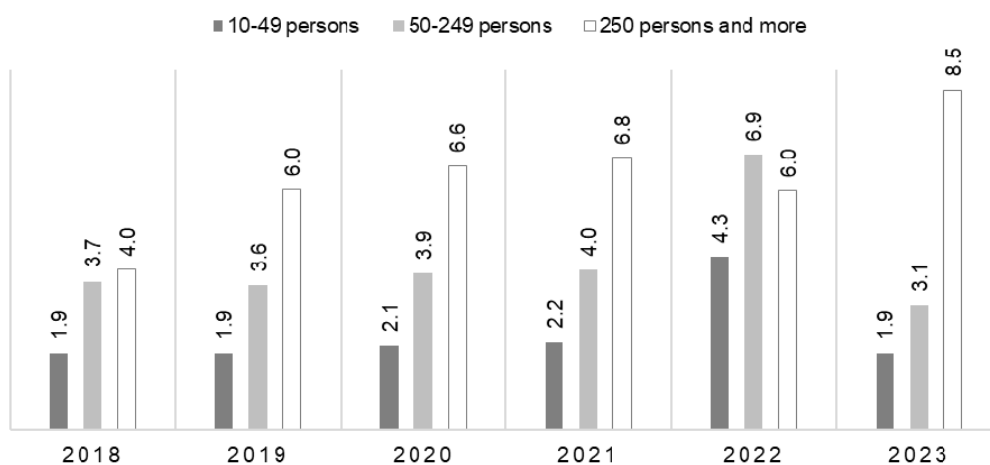


Fig. 10. The volume of products (goods, services) sold by enterprises received from e-commerce as a percentage of the total volume of products (goods, services) sold by enterprises

Source: compiled by the authors based on data from the State Statistics Service of Ukraine (2024): use of information and communication technologies at enterprises: e-commerce, invoicing 2018–2023.

Small businesses had a consistently low level of e-commerce until 2021 of about two percent. In 2022, there was a sharp jump to 4.3 percent, the highest for the period, which is seen as a reaction to martial law, relocation, and the growth of online sales. In 2023, there was a return to the level of 2018–2021 (1.9 percent). Accordingly, small businesses temporarily intensified e-commerce in the crisis year but were unable to sustain it.

Medium-sized enterprises showed a steady increase by 2022, from 3.7 to 6.9 percent. In 2023, there was a significant drop to 3.1 percent, which is almost half as much as in 2022. Accordingly, medium-sized businesses also increased online sales, but in 2023 may have returned to offline models or started losing market share due to competition.

Large enterprises showed the steadiest growth in the share of e-commerce from 4.0 percent in 2018 to 6.8 percent in 2021. There was a noticeable dip in 2022 – 6.0 percent, but a record growth in 2023 to 8.5 percent. Thus, large companies are actively scaling up e-commerce as a strategic direction, despite the crisis. Their share is the highest among all groups.

Large enterprises are the only ones that have consistently and strategically increased the share of online sales. Small businesses demonstrate reactive behavior – growth during the crisis, but a return to traditional models afterwards. Medium-sized businesses are losing momentum and need support to stabilize their e-commerce presence.

Analyzing the effectiveness and intensity of participation in foreign trade by enterprises of different sizes is important for identifying specific risks and barriers, assessing the

effectiveness of foreign trade strategies, identifying imbalances in the structure of exports and imports, and optimizing institutional support tools for enterprises.

In view of this, it is advisable to combine economic and statistical analysis with the analytics of FEA. For this purpose, it is proposed to use an index approach to analysis. Such an analysis will allow us to consider the efficiency and intensity of participation in FEA of different groups of enterprises by the number of employees in accordance with their potential and level of resource provision.

It is proposed to build integral indices of FEA in the following stages:

Stage 1. Building a model of integral indices and determining the indicators for the indices.

Stage 2. Normalization of indicators.

Stage 3. Construction of integral indices.

Stage 4. Interpretation of indices.

Stage 5. Analysis of the results obtained.

Each stage of the proposed methodology is considered separately.

Stage 1. Building models of integral indices and determining indicators.

To identify enterprises by the number of employees with the greatest potential and digital readiness to enter international markets, it is proposed to build three group integral indices:

- export capacity – Y_1 ;
- import activity – Y_2 ;
- total involvement in foreign trade – Y_3 .

Export capacity index:

$$Y_1 = f(X_1; X_3; X_5; X_7).$$

Import activity index:

$$Y_2 = f(X_2; X_4; X_6; X_7).$$

Index of total involvement in foreign trade:

$$Y_3 = f(X_1; X_2; X_3; X_4; X_5; X_6; X_7; X_8).$$

The following indicators were selected for this purpose:

X_1 – percent of the share of exports in the total sales of the section;

X_2 – percent of the share of imports in the total sales of the section;

X_3 – exports per employed worker, thousand USD;

X_4 – imports per employed worker, thousand USD;

X_5 – exports per UAH of personnel costs, UAH;

X_6 – imports per UAH of personnel costs, UAH;

X_7 – volume of sold products per employed worker, UAH thousand;

X_8 – volume of products (goods, services) sold by enterprises received from e-commerce as a percentage of the total.

Table 2 selects the rationale for selecting indicators for the integral indices of intensity of participation in FEA.

Table 2

Rationale for selecting indicators for the integrated assessment of the intensity of SMEs' involvement in foreign trade

Indicator	Justification
Share of exports in sales	Reflects the intensity of involvement in foreign markets; the higher the share, the greater the export focus of enterprises
Share of imports in sales	Determines external integration into the value chain. It may indicate involvement in international cooperation or dependence on imported raw materials
Exports per employed person	Indicates labor productivity in export activities. High values are a sign of efficiency and competitiveness
Imports per employed person	Indicates the scale of import operations at the level of one employee. Indicates technological modernization or logistics openness
Exports per UAH of personnel costs	Measures the efficiency of using personnel costs in export activities. This is the cost-benefit ratio in terms of foreign trade
Imports per UAH of personnel costs	How efficiently companies use labor costs in their import activities
Output per employee	Reflects the overall operational efficiency (labor productivity) of the enterprise. A high value indicates that the company potentially has the resources to scale up and internationalize. A low level indicates limited resources, which may be a barrier to international market entry
Percent volume of sales through e-commerce	E-commerce is a key tool for entering the international market, especially for SMEs. It reduces barriers to entry and allows sales abroad without a physical presence. The higher the share of e-commerce, the greater the digital readiness and potential for global reach

Source: created by the authors.

Imports are important for participation in international value chains, internationalization of supply, technological modernization, and preparation for exports through the renewal of the material base. The inclusion of imports in the integrated assessment of FEA is quite justified, especially in the context of general openness to the international market. Exports are a basic and critical element of SMEs' FEA, which allows quantification of their international activity, determination of their readiness to integrate into global markets, and to identify the potential for expanding participation in other forms of FEA (imports, international investment, partnerships).

The share of sales through e-commerce in total sales should be included in the overall index of foreign trade participation, as it expands the ability of SMEs to enter the international market.

Sales per employee should be included in the general indices of export capacity and import activity as an indicator

of operational efficiency and used for the general index of foreign trade participation.

Stage 2. Normalization of indicators.

To evaluate the proposed indices, it is proposed to use the method of normalization of variables: "Min-Max scaling". This is a method of linear transformation of input values into a certain interval, most often [0; 1], where the normalized value of the indicator (X_{inorm}) is determined by the formula:

$$X_{inorm} = \frac{X_i - X_{imin}}{X_{imax} - X_{imin}}, \quad (1)$$

where: X_i is the current value of the indicator; X_{imin} is the minimum value in the sample of enterprises with different numbers of employees; X_{imax} is the maximum value in the sample of enterprises with different numbers of employees.

The rationale for choosing the Min-Max normalization method is based on several important methodological, logical, and practical advantages:

1. This method is convenient and easy to use, as the obtained values fall within the range [0;1], where 1 is the

best result and 0 is the worst. This simplifies comparison and ranking.

2. This normalization is suitable for different indicators. Since the units of measurement of the indicators selected for analysis are different, it is necessary to normalize the indicators by bringing them to a single scale.

3. This method takes into account the relative difference between values. For example, an enterprise with three times higher exports will receive a significantly higher index. In particular, Z-normalization (standardization) is poorly suited if the distribution is not normal, and there are difficulties in interpreting the results (values > 1 or < 0). When using rating scaling (ranks), information about absolute differences between indicators is lost. Using a logarithmic transformation complicates interpretation, requires strictly positive values, and can "smooth out" important differences between indicators.

4. This method is easily implemented in Excel without any special software. It is convenient for processing statistical data by year.

5. All indicators have the same impact on the index (no need for weighting).

6. There are no significant outliers that can distort the results, as Min-Max is sensitive to extreme values.

7. Easy interpretation of the results: indices "close to 1" can be easily interpreted as high.

Stage 3. Construction of integral indices.

Integral indices Y_j (j – integral index index; Y_1, Y_2, Y_3 – indices of export capacity, import activity, and overall involvement in FEA, respectively) are calculated using the following formula:

$$Y_j = \frac{\sum_{i=1}^n x_{inorm}}{n}, \quad (2)$$

where n is – number of indicators in the group for assessing the j -th index.

Figure 11 shows the results of the assessment of the export capacity index of enterprises of different sizes by the number of employees in 2018–2023 according to the proposed methodology.

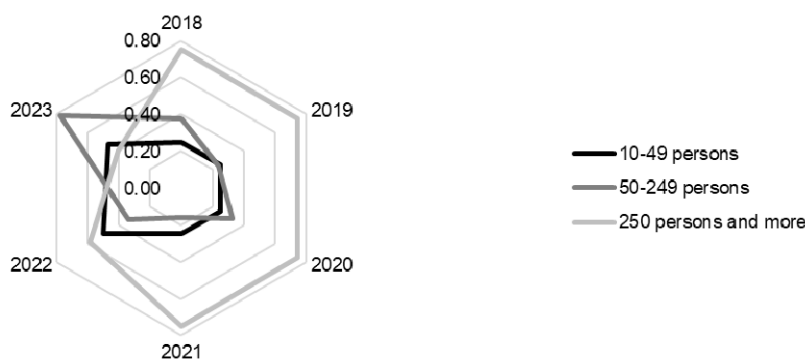


Fig. 11. The export capacity index of enterprises of different sizes for 2018–2023

Source: calculated by the authors based on the State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023; State Statistics Service of Ukraine (2024): exports of goods by economic entities by number of hired workers by types of economic activity from 2016 through 2023.

Small enterprises in 2018–2021 demonstrate a consistently low level of export capacity (0.25), which indicates a limited potential for exports or no changes in the foreign economic strategy. In 2022–2023, there is a noticeable increase to 0.50 (2022) and 0.47 (2023). The conditions of martial law and relocation, digitalization, and temporary customs privileges may have encouraged small businesses to enter foreign markets. The growth also reflects an improvement in relative efficiency or a reduction in the total number of active enterprises, which affects export capacity.

Medium-sized enterprises show an unstable trend from 0.38 (2018) to a record low of 0.16 (2021), and then a sharp jump to 0.78 in 2023. Medium-sized business activities likely decreased during 2020–2021 (COVID-19). In 2023, exports intensified due to the simplified regime of entering the EU market, adaptation to European standards, and digital solutions. The indicator of 0.78 is the highest among all in 2023, a sign of the reorientation of the structure of Ukrainian exports to medium-sized businesses.

In 2018–2021, large enterprises had a constant maximum (0.75) – they are export leaders. In 2022, there was a sharp drop to 0.59, and in 2023, an even greater drop to 0.40. Large enterprises are losing their dominance in export capacity due to damage/seizure of production facilities (especially in the east and south); logistical problems; focus on volumes rather than flexibility; and reduced competitiveness in the new environment.

Based on the study, the following conclusions can be drawn. Medium-sized businesses demonstrate the highest dynamics of growth in export potential, especially in times of crisis. Small businesses have shown moderate but stable growth, which may be a sign of their readiness to expand with proper support. Large enterprises are rapidly losing their export capacity, which signals a structural transformation of Ukraine's foreign trade.

Figure 12 shows the results of estimating the index of import activity of enterprises of different sizes by the number of employees in 2018–2023 using the proposed methodology.

Small enterprises are the most stable group with an import activity value of 0.60 ± 0.01 over 6 years. A slight decrease was observed in 2023 to 0.58. Small businesses maintain a stable dependence on imports (finished goods, raw materials). This stability may indicate both limited opportunities for import substitution and narrow specialization in trade.

Medium-sized enterprises show a sharp decline from 0.49 (2018) to 0.22 (2021), which may be due to a decrease in imports or difficulties with financing, logistics, and currency restrictions. In 2022, there was a sharp increase to 0.80, and in 2023, a slight decrease to 0.72. In 2022–2023, medium-sized businesses intensified their import activities, which were aimed at resuming production, supplying critical components, and securing new market opportunities after relocation or restructuring.

Large enterprises showed the most stable values in 2018–2021 of 0.50. In 2022, there was a drop to 0.41, and in 2023, a return to 0.50. In 2022, large enterprises reduced imports due to: supply chain disruptions (martial law), changing priorities (reorientation to the domestic market, localization), and problems with currency settlements. At the same time, in 2023, they restored the pre-war level of import activity, which indicates adaptation to new conditions.

Based on the study, the following conclusions can be drawn. Medium-sized enterprises became the most active

importers among all groups in 2022–2023. Small enterprises are stable consumers of imported products, which indicates a conservative business model. Large enterprises have an adaptive potential, but their import activity was suppressed during the military crisis.

Figure 13 shows the results of assessing the index of total foreign trade involvement of enterprises of different sizes by the number of employees in 2018–2023 using the proposed methodology.

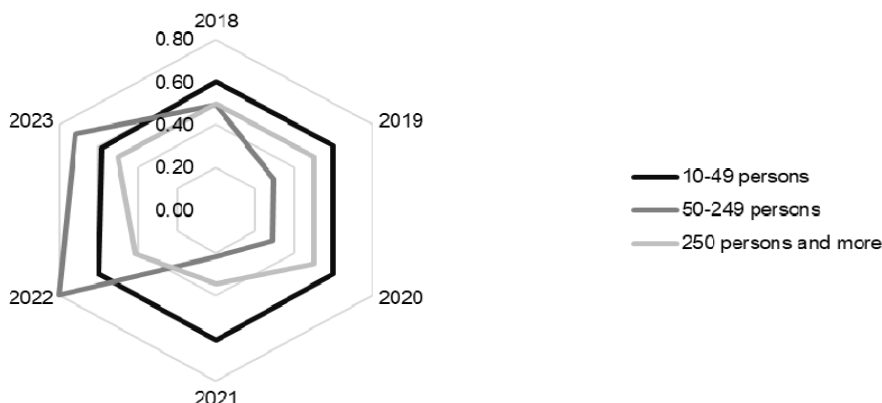


Fig. 12. Index of import activity of enterprises of different sizes in 2018–2023

Source: calculated by the authors based on the State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small, and micro-entrepreneurship by type of economic activity in 2013–2023; State Statistics Service of Ukraine (2024): import of goods by economic entities, by number of hired workers, and by types of economic activity from 2016 through 2023.

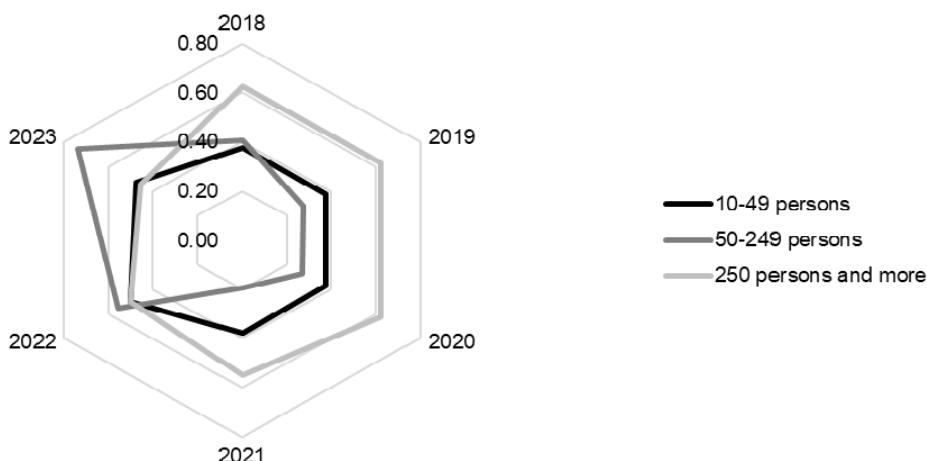


Fig. 13. The index of total involvement in FEA of enterprises of different sizes in 2018–2023

Source: calculated by the authors based on State Statistics Service of Ukraine (2024): value of output of entities of large, medium, small and micro-entrepreneurship by type of economic activity in 2013–2023; State Statistics Service of Ukraine (2024): use of information and communication technologies at enterprises: e-commerce, invoicing 2018–2023; State Statistics Service of Ukraine (2024): exports of goods by economic entities, by number of hired workers, and by types of economic activity in 2016–2023; State Statistics Service of Ukraine (2024): import of goods by economic entities by number of hired workers by types of economic activity from 2016 through 2023.

The assessment indicates that small enterprises have a consistently low level of the index of general involvement in foreign trade in 2018–2021 (0.38), followed by a jump in 2022 to 0.50 and a slight decrease in 2023 to 0.47. This shows that small businesses became significantly more active in foreign trade during the crisis year of 2022 due to adaptation to changes, searching for new sales channels, and participating in the import of critical goods. In 2023, activity remained at an elevated level.

Medium-sized enterprises are the most dynamic group, showing a drop from 0.40 (2018) to 0.19 (2021), and an increase to 0.55 (2022) and 0.74 (2023). This is the highest figure among all groups in 2023. Medium-sized businesses,

after falling in previous years, have sharply intensified under martial law. This was due to management flexibility, partial localization of production, rapid digital transformation, and export support (from platforms, projects, and donor programs).

Large enterprises were stable leaders in 2018–2021 (0.63), demonstrating the highest level of involvement in foreign trade. In 2022, there was a drop to 0.50, followed by a further decline in 2023 to 0.45. Big business has lost its dominant position in foreign trade due to destruction/seizure of assets, logistical constraints, closure of ports, reduction of production capacity, and problems with large-scale exports in wartime.

Medium-sized enterprises are the new leaders in overall engagement in foreign trade. In 2023, their integral index is the highest (0.74). Small enterprises show a gradual intensification, especially after 2021. Large enterprises have lost their advantage, which may be the result of a structural crisis caused by martial law, relocation, and a drop in production.

Stage 4. Interpretation of the indices.

It is proposed to use a linear scale to interpret the integral indices. The use of "Min-Max" normalization, which converts all indicators into the interval [0, 1], is logically continued by the use of a linear scale to interpret the results (Table 3). This allows for a clear, consistent, and objective interpretation of the results.

Table 3

Interpretation of the obtained indices

Index	Interpretation
0.76–1.00	High level (HL). Enterprises have strong external integration, technological readiness, and competitiveness. Full or high ability to carry out FEA, export (import) strategy, experience, and sales channels
0.51–0.75	Medium level (MedL). There is some participation in foreign trade, but with limited potential. Partial readiness has been formed; sporadic participation in foreign trade or export (import) through intermediaries is possible, support or strategic rethinking is needed
0.26–0.5	Moderate level (ModL). Limited use of FEA instruments. FEA is sporadic or fragmented. Single attempts at export or import, lack of a coherent strategy/resources. Weak or absent strategy for entering foreign markets
≤ 0.25	Low level (LL). Minimal or no participation in foreign trade. The index indicates the absence of systematic participation in foreign trade or extremely low capacity. Enterprises are focused on the domestic market, often due to resource or institutional constraints

Source: compiled by the authors.

Stage 5. Analysis of the results.

The following measures can be proposed to stimulate export capacity, import activity, and overall foreign trade capacity for enterprises of different sizes.

The following recommendations are proposed to balance export capacity:

- Reconfigure export policy to support medium-sized businesses as new leaders.
- For small businesses, develop export accelerators, e-commerce, and B2B platforms.
- Large enterprises need to invest in modernization, logistics, and production resumption.

Recommendations for balancing import activity:

- For medium-sized enterprises, support for the development of domestic production chains to reduce dependence on imports.
- For small enterprises, training on the possibilities of import substitution, local production, or transformation into exporters.
- For large enterprises, institutional support for logistics, customs clearance, and currency regulation is needed to mitigate risks in times of turbulence.
- General recommendations for balancing foreign trade:
 - The focus of state foreign trade policy should shift to supporting medium-sized businesses that demonstrate high adaptability and flexibility.
 - Small businesses need institutional support to maintain the pace of integration into foreign trade (digital infrastructure, logistics, training).

- Large companies need targeted recovery programs: investments in production, infrastructure, and transport corridors.

The European Bank for Reconstruction and Development (2023) (EBRD) commissioned a study "Problems and needs of SMEs almost a year after the start of the war". Barriers to doing business included loss of part of the production capacity (equipment, personnel), lack of funds to pay for rented premises (payment is due upon signing the contract, but moving takes several months), inflated prices in the rear, difficulties with equipment installation (lack of necessary equipment, specialists), unsatisfactory condition of premises available for rent (lack of repair, toilets, etc.), the requirement for businesses to invest heavily in leased premises on their own, inspections by controlling authorities (State Consumer Service, SES),

significant investments in equipment of premises in accordance with state requirements, disorientation of managers in a new location (no networking, no information center for relocated businesses), difficulties in finding premises for rent (rarely: some SMEs were provided with premises by the authorities).

According to the assessment of the impact of martial law on micro, SMEs in Ukraine (United Nations Development Program in Ukraine, 2024), the largest obstacles to the integration of SMEs with the European market are the lack of European partners, financial resources, and qualified specialists.

The lack of European partners is due to the lack of awareness of Ukrainian companies about cooperation opportunities, the lack of established contacts with the EU business community, and the low level of trust of European partners in Ukrainian enterprises due to the risks of martial law. To improve the situation, it is necessary to create public and private platforms for finding partners in the EU, organize business forums, exhibitions, and B2B meetings with European companies, and introduce government programs to support international partnerships for SMEs.

Intensive participation in trade missions, exhibitions, and international business networking has become not only a response to the challenges of recent years but also a strategic response of Ukrainian business to the need to find new markets, partnerships, and ways to integrate into the global economy. Accordingly, during 2020–2023, about 2,500 Ukrainian companies participated in 34 trade missions, 24 international exhibitions, and more than 50 international B2B events (National Council for the Recovery of Ukraine, 2022).

The lack of financial resources is a result of limited access to credit due to high interest rates and instability of the banking system, high costs of certification of products according to European standards, and a lack of sufficient state support for exporters. To solve this problem, financial support and access to investment are needed, including the expansion of EU grant programs for Ukrainian enterprises (Horizon Europe, EBRD, USAID), the launch of state programs to compensate for the costs of certification and access to the European market, and the development of public and private funds to support export-oriented businesses.

The shortage of qualified specialists is a result of the outflow of personnel abroad due to martial law and economic instability, insufficient knowledge of international trade, certification, and work with European markets, and a lack of specialists with knowledge of European languages and EU business culture. To overcome this problem, it is necessary to develop human resources, namely to implement educational programs and training on international trade for SMEs, standardization and certification, to encourage the return of specialists from abroad (grants, preferential business conditions), and to strengthen cooperation between universities and businesses to train specialists in export and international business.

Since 2016, the policy of supporting SMEs' foreign trade in Ukraine has evolved from strategic declarations to the creation of institutions, digital tools, and anti-crisis mechanisms. Currently, the key vectors are digitalization, partnership with the EU, adaptation of standards, e-commerce support, and participation in global platforms. The internationalization of SMEs is supported through the adoption of a new Export Strategy, increased transparency, and expansion of support programs to integrate SMEs into the GVC and promote e-commerce (OECD, 2024). This includes conducting an independent review and publishing a list of beneficiaries of export promotion programs.

The survey of Ukrainian SMEs identified the top ten options for support other than a loan, including assistance with business reconstruction (grant) (35 percent), grant (non-repayable financial assistance for various purposes) (32 percent), advice from companies that have been in a similar situation and coped with it (25 percent), experience of international companies in a similar field in their market (22 percent), establishing international partnerships in times of war (21 percent), participation in international exhibitions (19 percent), expertise from a local consultant, (16 percent), expertise from a local or international expert on entering new markets (14 percent), expertise from a local consultant who knows the business region with 85 percent, reimbursement of project costs or an international consultant with 100 percent reimbursement – 13 percent, consulting (accounting, law, marketing, strategy, etc. – 11 percent (European Bank for Reconstruction and Development, 2023). Problems and needs of SMEs almost a year after the start of the war).

In Ukraine, support for SMEs' integration into the global value chain is only at its initial stages. However, the Diia.Business project (Ministry of Digital Transformation of Ukraine, n.d.-b), as well as several export promotion activities conducted by the Export Ecosystem Development Office (EEPO), are helping SMEs become part of global production and trade networks (OECD, 2024; Ionan, 2022). The EEPO is an institutional platform that provides systemic support for exports, especially for small and medium-sized businesses (SMEs), through the coordination of various elements of the system: digital services, education, finance, and institutions. EEPO supports digital transformation by providing online courses for SMEs. The Ministry of Digital Transformation of Ukraine is also working to promote the use of artificial intelligence (AI) technologies by businesses and establish AI governance rules, aligning them with EU rules.

It is not only the country's resource potential and production capacity that create conditions for foreign trade. In Ukraine, exports account for a small share of the country's total value added. However, in 2022, Ukraine managed to increase exports of services, in particular telecommunications, computer and information services (40.5 percent of total exports of services), transportation

(32.3 percent), and business services (11.2 percent) (OECD, 2025).

The introduction of martial law has exacerbated existing problems for SMEs in Ukraine and created new barriers related to supply chain disruption, limited access to finance, physical insecurity, and infrastructure losses. In response, businesses were forced to intensify their search for foreign markets, partnerships, and alternative logistics solutions.

Ukrainian SMEs face objective barriers to international market entry due to martial law, weak institutions, insufficient resources, and human resource constraints. However, the availability of international support, the development of digital tools, institutional integration, and the strengthening of human resources can turn export and import activities into a sustainable growth vector.

Discussion and conclusions

To test the first hypothesis, composite indicators for evaluating export capacity, import activity, and the overall degree of enterprise participation in foreign economic activity were constructed using statistical data for 2016–2023. This approach enabled a comparative analysis of dynamic changes across enterprise size categories.

The analysis indicates that small enterprises exhibit adaptive behavior under crisis conditions, primarily through the utilization of digital channels for international trade. Although their engagement in foreign economic activity remains less extensive than that of medium or large enterprises, they demonstrate potential for sustainable growth, contingent upon continued digitalization, localized support, and the development of micro-export infrastructure.

Medium-sized enterprises represent the most flexible segment of SMEs, capable of responding promptly to market fluctuations, provided that adequate incentives, digital infrastructure, and foreign economic support mechanisms are available. This group appears particularly promising for scaling up participation in international trade during the subsequent phases of public policy implementation.

In contrast, large enterprises, despite showing substantial recovery in foreign economic activity in 2023, remain more susceptible to structural shocks, emphasizing the need to reassess strategies for supporting this segment.

The integrated assessment of overall enterprise participation in foreign economic activity reveals a shift in leadership: while large companies dominated during 2018–2021, since 2022, medium-sized enterprises have taken the lead, demonstrating superior adaptability to changing conditions. This finding is consistent with the OECD SME Policy Index: Eastern Partnership Countries (2024), which attributes their resilience to rapid digital transformation and optimization of production capacity. Small enterprises show steady, though gradual, progress. These structural changes underscore the necessity of reorienting state foreign economic policy toward medium-sized enterprises as a critical source of economic stability and expansion.

Given current trends, the digitalization of foreign economic activity remains a key vector for enhancing the competitiveness of Ukrainian SMEs. Further growth in their export potential may be achieved through the development of e-commerce, participation in international marketplaces, digital marketing, and the application of data analytics in strategic decision-making.

The study also identified several systemic barriers that constrain SME integration into foreign markets, including limited access to finance, complex certification procedures aligned with international standards, insufficient digital maturity, and a lack of foreign trade competencies. These challenges require

targeted interventions from the government, international donors, and business associations.

Consistent with the second hypothesis, a balanced rationale for the intensification of foreign economic activity among Ukrainian SMEs was developed for each enterprise size category (small, medium, and large). The recommendations incorporated observed trends in export capacity, import activity, overall SME engagement in foreign economic activity, and the identified barriers to internationalization.

Future research should focus on regional differentiation in SME foreign trade activity, the impact of digital export tools on business model efficiency, and the integration of Ukrainian SMEs into global value chains, with consideration for sectoral characteristics and technological development levels.

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КІЛЬКІСНА ОЦІНКА ІНТЕРНАЦІОНАЛІЗАЦІЙНОГО ПОТЕНЦІАЛУ МАЛИХ І СЕРЕДНІХ ПІДПРИЄМСТВ

Вступ. Досліджено проблему залученості підприємств малого і середнього бізнесу України до зовнішньоекономічної діяльності в умовах глибоких структурних змін, спричинених війною, трансформацією глобальної економіки та цифровізацією. Актуальність теми зумовлена необхідністю формування ефективної політики підтримки малого і середнього бізнесу для активізації експорту, імпорту й інтеграції в міжнародні ринки, що є критично важливими для відновлення економіки країни. Метою дослідження є кількісне оцінювання експортної здатності, імпортної активності та загальної залученості підприємств різного розміру до зовнішньоекономічної діяльності, а також виявлення бар'єрів і формулювання заходів для активізації інтернаціоналізації малого і середнього бізнесу.

Методи. Застосовано методи статистичного аналізу, порівняльного підходу, нормалізації показників (метод "мін-макс") та побудови інтегральних індексів. Проведено емпіричний аналіз статистичних даних Державної служби статистики України за 2016–2023 рр.

Результати. Результати показали, що мікро- та малі підприємства наростили ефективність експортної та імпортної діяльності, особливо у воєнний період, тоді як великі підприємства втратили динаміку (зокрема й експортну). Побудовано індекси експортної здатності, імпортної активності та загальної залученості до зовнішньоекономічної діяльності, що дозволило встановити лідерство середніх підприємств за експортною спроможністю у 2023 р. та зростання імпортної інтенсивності мікропідприємств. Виявлено бар'єри, пов'язані з нестачею фінансування, сертифікаційними труднощами, низькою цифровою готовністю.

Висновки. Практична цінність дослідження полягає у запропонованому інструментарії для оцінювання участі малого і середнього бізнесу у зовнішньоекономічній діяльності та рекомендаціях щодо підтримки їх інтернаціоналізації.

Ключові слова: малий і середній бізнес, зовнішньоекономічна діяльність, експортна здатність, імпортна активність, залученість до зовнішньоекономічної діяльності, цифровізація, електронна торгівля, бар'єри зовнішньоекономічної діяльності.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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ASSESSMENT OF THE COMPETITIVE ENVIRONMENT OF IT COMPANIES

Background. Ukraine's IT services market has remained a dynamic and export-oriented segment of the economy during the full-scale war, while undergoing consolidation, exits, mergers and acquisitions (M&A), and restructuring processes. Small and medium-sized enterprises (SMEs) are gaining visibility, yet competitive conditions remain ambiguous due to business groups comprising multiple legal entities. This study focuses on Ukraine's IT services market, examining the competitive environment and structural market asymmetries from 2022 to 2024. It aims to evaluate the level and dynamics of competition by analyzing market concentration and structural asymmetries during this period.

Methods. A system-structural approach is applied, using concentration metrics for firms classified under Classifier of Types of Economic Activities (KVED) sections 62 and 63. Indicators include the Herfindahl–Hirschman Index (HHI), concentration ratios (CR_3 , CR_5), the Gini Index, the Entropy Index, the Linda Index, and variance-based measures. Market shares are calculated from revenue; the SME share in total market revenue is also tracked. Descriptive statistics are complemented by comparative analysis across 2022–2024 on a research sample of 411 companies (13 large), with particular attention to the gap between the number of legal entities and verified active companies.

Results. The market exhibits complex corporate structures: 8.6 thousand legal entities provided IT services in 2024, but only 2,118 companies were verified as active. HHI fell from 433.68 (2022) to 170.86 (2024), signalling stronger competition. CR_3 declined from 26.18% to 17.77%, and CR_5 from 34.13% to 23.31%; the SME revenue share rose from 52.7% to 62.4%. Distribution-sensitive measures reveal a hybrid structure: high entropy ($E = 5.09$) and low variance indicate broad participation, whereas the Gini Index (0.601), the Linda Index (169.2%), and the Lorenz curve point to a dominant core in the upper segment. By business model, outsourcing firms prevail (47% in 2024), followed by product (31%), mixed (19%), and outstaffing (3%).

Conclusions. Ukraine's IT services market is moving toward a more competitive, decentralized configuration while an oligopolistic core persists. The simultaneous rise of SMEs and the weakening of top players' shares reduces monopolization risks, enhances resilience, and suggests growing value-added potential. Policy should balance SME entry and scaling with support for high-value, export-oriented capabilities through cooperation with market leaders. The proposed methodology can be applied to other high-tech markets, while future research should examine the links between concentration dynamics, financial stability, and the role of business models in shaping the competitive environment.

Keywords: IT services market, structural market asymmetry, market competition, oligopolistic market core, market concentration.

Background

Under the current conditions of full-scale war in Ukraine, small and medium-sized enterprises (SMEs) in the IT services market play a particularly important role in maintaining economic resilience and preserving the potential for high-tech development. They demonstrate flexibility, adaptability, and the ability to respond rapidly to changing circumstances. The IT services market remains one of the most dynamic and export-oriented sectors of the Ukrainian economy, ensuring foreign currency inflows and creating new jobs.

At the same time, this sector is experiencing processes of market concentration and consolidation (through mergers and acquisitions, bankruptcies of some companies, and the expansion of others), which may lead to reduced competition. For Ukraine, which is actively integrating into global IT value chains, the analysis of market concentration levels is of particular importance.

The object of this study is the IT services market of Ukraine, while the subject is the competitive environment and the structural asymmetries formed under the influence of market concentration and redistribution processes. The formulation and systematization of the state and dynamics

of IT services market concentration make it possible to identify potential risks of market dominance and provide a foundation for comprehensive research into the conditions for the development of small and medium-sized IT companies.

The purpose of this study is to determine the competitive conditions for the development of the domestic IT market.

Literature review. Korablinova and Kulbatska (2017) provided a concise analysis of the level of concentration in the global software market and identified the main challenges associated with comprehensive and reliable assessments of market concentration. Zavorodnia and Melnyk (2023) focused on the theoretical foundations of competition and the development of competitiveness in Ukraine's IT sector. Shthuler and Prestaya (2023) analyzed the current state of the IT services market in Ukraine and outlined possible development trends. Similarly, Lisik and Moriak (2023) examined the Ukrainian IT sector under the conditions of the full-scale war with Russia, emphasizing the specific risks and transformations triggered by the wartime economy.

The measurement of concentration in high-tech industries using the Herfindahl–Hirschman Index (HHI) has

been widely applied in international research. For instance, Bessen (2020) demonstrated that advances in information technology significantly influence industry concentration, reshaping competitive dynamics across sectors. In parallel, Autor et al. (2020) advance the "superstar-firms" hypothesis: rising concentration and markups reflect the growing weight of firms with superior intangible assets and software, with macroeconomic effects on the labor share. De Loecker and Eeckhout (2020) corroborate the aggregate rise in market power, showing substantial increases in markups concentrated in the upper tail of the firm distribution. Complementing these findings, Grullon, Larkin, and Michaely (2019) show that U.S. industry concentration rose in over 75% of industries since the late 1990s, with profitability gains tied more to margins than to efficiency – evidence consistent with increased market power rather than pure technological improvement. Together, these studies provide a baseline against which the wartime evolution of Ukraine's IT services market can be compared.

At the same time, theory cautions against a simplistic mapping from competition to innovation outcomes. Aghion et al. (2005) document an inverted-U relationship in which moderate product–market competition fosters "neck-and-neck" innovation, whereas excessive concentration dampens it. This perspective is particularly relevant for IT services, where modular production, outsourcing/product/mixed business models, and rapid capability reconfiguration can sustain vigorous rivalry even alongside a persistent upper-tier core of large firms. It motivates the use of multiple indicators (HHI, CR_n , Gini/inequality measures, and Linda/entropy-type indices) to diagnose whether observed structural asymmetries amount to harmful dominance or to a competitive hybrid consistent with innovation and resilience.

Identification of previously unresolved aspects. Despite the considerable number of publications devoted to the characteristics, challenges, and prospects for the development of the IT market, as well as to the formation of competitiveness among IT companies, the issues of assessing the level of market concentration and its competitiveness remain insufficiently addressed. The degree of market concentration directly influences the strategic behavior of companies operating within it and seeking to maintain their competitiveness. This aspect is

particularly important for small and medium-sized enterprises (SMEs), whose primary task under current challenges is not only survival but also strengthening their positions in a highly concentrated market.

Methods

The methodological framework for analyzing the IT services market in Ukraine was based on a combination of general scientific and specialized methods of economic analysis, including:

- system-structural method – used to analyze the characteristics of the functioning of the Ukrainian IT services market, its structural features, and the distribution of companies by size;
- economic and mathematical methods – applied to calculate quantitative measures of market concentration, including the Herfindahl–Hirschman Index (HHI), concentration ratios (CR_3 , CR_5), the Gini Index, the Entropy Index, and the Linda Index;
- formalization method – used to present the results in the form of generalized statistical indicators reflecting the level of market concentration and competitiveness;
- comparative analysis – employed to compare the dynamics of concentration indicators in 2022–2024 and to cross-check the results obtained from different measures, enabling a comprehensive characterization of structural changes in the IT services market.

The use of concentration indices (HHI, CR_n , Gini, Entropy, Linda) corresponds to modern approaches to structural market analysis, which have also been applied in other sectors of the national economy, including the banking services market (Ihnatiuk, & Kolosha, 2024).

Results

The Ukrainian IT services market is characterized by a complex corporate structure, which reflects the specific features of doing business in the digital economy. According to the State Tax Service of Ukraine and IT Research Ukraine (2024), about 8.6 thousand legal entities providing IT services operated in Ukraine in 2024 (Fig. 1), which is 5.9% more than in 2023. The increase in the number of IT companies may indicate a gradual recovery of the market to its pre-war scale (in 2021, the number of such legal entities amounted to 9.6 thousand).

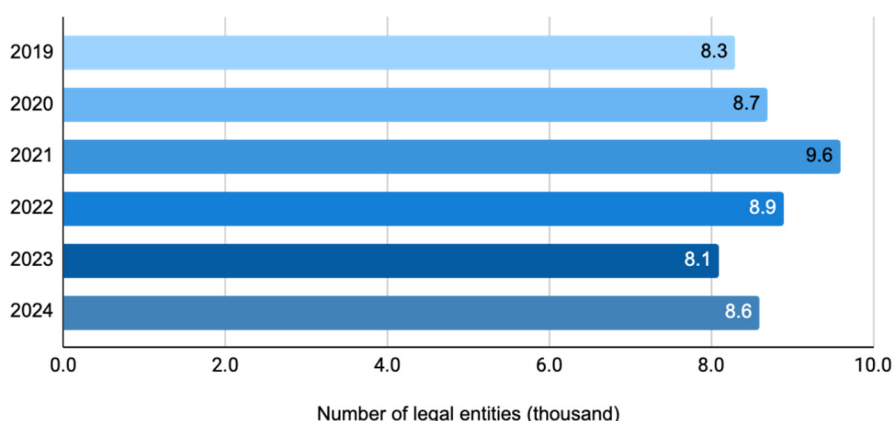


Fig. 1. Dynamics of the number of legal entities providing IT services in Ukraine, 2019–2024, thousand entities

Source: developed by the authors based on data from the State Tax Service of Ukraine and Lviv IT Cluster.

However, it should be noted that the number of registered IT companies is not identical to the number of those actually operating. This is because a single company may include several legal entities registered to serve

different business areas or models. In 2024, the number of verified active IT companies in Ukraine amounted to 2,118 units – almost four times fewer than the number of registered legal entities. Such a gap between the number of

companies and legal entities complicates the accurate assessment of the IT services market structure and requires consideration in the chosen analytical methodology.

To conduct a more in-depth analysis of the IT services market structure in Ukraine, particularly in the context of the transformational period of 2022–2024, a comprehensive assessment of market concentration levels was carried out. This analysis makes it possible to identify key changes in the balance of power among major players as well as to reveal trends towards monopolization or, conversely, towards increasing competition in the market.

The primary source of information for the study of the Ukrainian IT services market was the set of enterprises whose activities, according to the Classification of Types of

Economic Activity (KVED), fall under Section 62 "Computer programming, consultancy, and related activities" and Section 63 "Information service activities." This choice is explained by the fact that these sections cover enterprises directly involved in software development, implementation, maintenance, and consulting, as well as in the provision of information services, including data processing, hosting, and related information resource activities. Therefore, they are representative of capturing the key processes and development trends of the domestic IT services market.

The research sample included 411 companies, among which 13 enterprises were classified as large according to the current criteria for classifying business entities by size (Table 1).

Table 1

Market shares of major IT companies in Ukraine, 2022–2024

Company	Market share (%)		
	2022	2023	2024
LLC "GLOBALLOGIC UKRAINE"	9.14	7.64	6.79
LLC "EPAM SYSTEMS"	16.05	8.44	6.60
LLC "EPAM DIGITAL"	0.99	4.02	4.38
LLC "LUXOFT SOLUTIONS"	4.72	3.93	3.17
LLC "INSTITUTE OF INFORMATION TECHNOLOGIES INTELLIAS"	3.23	2.90	2.36
LLC "SOFTSERVE TECHNOLOGIES"	0.05	1.56	2.23
LLC "FINTECH BAND"	1.78	3.73	2.16
LLC "HIGHLOAD SOLUTIONS"	0.00	0.69	1.88
LLC "CIKLUM"	3.83	2.56	1.86
LLC "TIETOEVRVY CREATE UKRAINE"	2.67	2.16	1.78
LLC "MEGOGO"	1.30	1.48	1.62
LLC "SQUAD UKRAINE"	0.00	0.63	1.51
LLC "SOFTSERVE DIGITAL"	0.41	0.42	1.30

The formal parameters most frequently used to assess market concentration include:

1. The number of sellers;
2. The distribution of market shares among individual market participants.

The IT services market is no exception. To calculate a concentration indicator, it is first necessary to determine the market shares of individual entities. The market share of the i -th entity is most commonly defined as the ratio of the value of goods or services sold by this entity (Q_i) to the total sales volume in the market (Q_r) over the corresponding period (Equation 1):

$$Y_i = \frac{Q_i}{Q_r}. \quad (1)$$

In global practice, several indices and measures are used to assess the level of market concentration. First, we calculated the indices traditionally applied in economic theory and antitrust regulation:

- concentration ratios (CR_3 and CR_5), which capture the share of revenue accumulated by the three and five largest companies, respectively;
- Herfindahl–Hirschman Index (HHI), which provides an aggregated representation of concentration by summing the squares of the market shares of all market participants;
- the share of small and medium-sized enterprises (SMEs) in total market revenue, calculated as the ratio of the combined revenue of all companies meeting SME criteria to the total revenue of all market participants.

This approach is consistent with the theoretical conclusions of Kvålseth (2018), who demonstrated the functional relationship and complementarity among these indicators.

It should be noted that the concentration ratio is measured as the sum of market shares (k_i) for m largest companies out of the total number n of companies operating in the same product market (Equation 2):

$$CR = \sum_{i=1}^m k_i, \sum_{i=1}^n k_i = 100\%. \quad (2)$$

Based on the data on the market shares of the largest entities, it is possible to trace the dynamics of the concentration index for the four largest (CR_4) and eight largest (CR_8) IT companies (Table 2).

Another widely used indicator for assessing market concentration is the Herfindahl–Hirschman Index (HHI), which is calculated as the sum of the squared market shares of all firms operating in the market (Equation 3):

$$HHI = \sum_{i=1}^n q_i^2, \quad (3)$$

where q_i^2 is the squared market share of the individual IT company, expressed as a percentage.

The concentration ratios and the Herfindahl–Hirschman Index are important indicators of market structure that make it possible to identify the overall dynamics of economic activity distribution within the market. The calculation results are presented in Table 2.

Table 2

Indicators of the IT Services market structure in Ukraine, 2022–2024

Year	HHI Index	CR ₃ (%)	CR ₅ (%)	SME Revenue Share (%)
2022	433.68	26.18	34.13	52.72
2023	228.29	20.09	26.93	56.91
2024	170.86	17.77	23.31	62.35

Source: compiled by authors.

The values of the Herfindahl–Hirschman Index (HHI) during 2022–2024 demonstrate a clear downward trend: from 433.68 in 2022 to 170.86 in 2024, indicating a gradual increase in the level of competition in the IT services market. In this study, the HHI was calculated in the format adopted in antitrust practice, where market shares are expressed as percentages, and the resulting sum of the squared shares ranges from 0 to 10,000. This approach is appropriate as it allows for direct comparison of the obtained values with the concentration thresholds used by regulatory authorities, including the U.S. Department of Justice (US DOJ) and the Federal Trade Commission (FTC).

In the context of antitrust regulation, it is generally accepted that on a 0–10,000 scale, HHI values below 1,000 correspond to highly competitive markets, values between 1,000 and 1,800 indicate a moderately concentrated market, and values above 1,800 are characteristic of highly concentrated markets (U.S. Department of Justice, 2024).

Thus, the obtained results indicate that the Ukrainian IT services market falls within the zone of high competition, and its concentration level continues to decrease. Overall, this points to structural changes, particularly the weakening of the positions of certain large companies and the increasing influence of medium-sized and small enterprises.

It should be noted that the Herfindahl–Hirschman Index (HHI) is considered one of the most reliable tools for assessing market concentration, especially in industries with a high level of intellectual capital and low barriers to entry, such as the information technology market. Its advantage lies in its sensitivity to changes in the market shares of even smaller participants, making it possible to capture very minor shifts in the competitive environment (PLOS One, 2022).

Alongside the decline in the overall concentration level measured by the Herfindahl–Hirschman Index (HHI), a similar downward trend is observed in the concentration ratios of the three and five largest companies (CR_3 and CR_5). Specifically, the CR_3 indicator decreased from 26.18% in 2022 to 17.77% in 2024, while CR_5 dropped from 34.13% to 23.31% over the same period. This indicates that the combined revenue share accumulated by the largest market participants has significantly declined, leading to a more fragmented market structure.

These changes reflect a gradual diversification of the market structure, where small and medium-sized enterprises (SMEs), as well as new or niche companies, are beginning to play a more prominent role in shaping the total revenue of the IT services market. Under the dynamic conditions triggered by military and economic shocks, this may point to the high adaptability and flexibility of the less concentrated market segment, which can effectively respond to changes in demand, technological challenges, and the transformation of global value chains.

Contemporary literature emphasizes that the use of the Herfindahl–Hirschman Index (HHI) and concentration ratios (CR_n) constitutes a sound methodological framework for analyzing the competitive environment. These indicators enable a comprehensive assessment of both the overall level of market concentration and the distribution of shares among market participants. In particular, Peleckis (2022), examining the methodological aspects of structural analysis, highlights the appropriateness of applying these indicators to identify the level of competitiveness and evaluate transformation dynamics across various sectors of the economy.

Notably, the share of small and medium-sized enterprises (SMEs) in the total revenue of the IT services market increased from 52.7% in 2022 to 62.4% in 2024. This positive trend indicates the gradual strengthening of SMEs' positions in the

market structure and their growing contribution to the overall revenue generation in the IT services market.

The increase in the SME share in the IT services market can be viewed as one of the manifestations of this segment's adaptive potential, particularly in the context of prolonged crises associated with full-scale war, business relocation, disrupted supply chains, and the transformation of global demand for IT services.

The increasing share of SMEs also reflects the high level of innovation activity and entrepreneurial dynamism in the market, driven by the development of startup culture, remote work models, and the creation of highly specialized niche solutions targeting global markets. This trend indicates not only the ongoing restructuring of the market but also potential shifts in the long-term competitive strategy of Ukraine's IT services market, where SMEs are emerging as key drivers of resilience and recovery.

Thus, the growing market weight of small and medium-sized IT companies represents not only a quantitative change but also qualitative evidence of the strategic transformation of the market toward a decentralized, adaptive, and more resilient development model.

For comprehensively measuring the level of market concentration and structural differentiation in the IT services market in Ukraine, this study employs a system of quantitative indicators that allow for the assessment of both the overall level of competition and the presence of structural asymmetries among market participants. These indicators include the Entropy Index, the variance of market shares, the variance of the logarithms of shares, the Gini Index, and the Linda Index. Each of these measures captures different aspects of market structure, ranging from the degree of uniformity in the distribution of shares among all participants to the dominance of leading companies. Their combined use ensures a multidimensional approach to analyzing the competitive environment, enabling the identification of both general decentralization trends and localized manifestations of concentration, which are critical for shaping adaptive market development strategies (Table 3).

The Entropy Index ($E = 5.09$) indicates a high level of market fragmentation in the IT services sector, which is typical for competitive environments with a large number of active players. Such a level of entropy suggests the absence of dominance by individual entities and a relatively even distribution of market shares among companies of different sizes. In the context of the transformation of Ukraine's IT services market, this is a sign that the market has the potential for sustainable development through internal diversification and the growing share of medium-sized and small enterprises.

The variance of market shares ($\sigma^2 = 0.0000356$) demonstrates a slight deviation of companies' market shares from the average value, confirming the presence of relatively balanced competition across a significant part of the market. This indicator is particularly valuable for analyzing a broad base of service providers with similar levels of commercial influence. In the case of the IT services market, it suggests that the institutional environment supports relatively equal access to market resources, at least beyond the dominant core.

The variance of the logarithms of market shares ($\sigma^2_{\log} = 0.7275$) reveals moderate inequality in the distribution of market shares, with increased sensitivity to extreme values. This indicates the existence of significant differences between leading companies and the mass of less influential firms, which is typical for markets with complex hierarchical structures. For the Ukrainian IT services market, it means that despite the overall competitive background, vertical differentiation persists, whereby some entities accumulate significantly more resources and client segments.

Table 3

Results of the calculation of concentration indices for the IT services market

Indicator	Formula	Description	Value
Entropy Index (E)	$E = \sum_{i=1}^n \left(q_i \cdot \ln \left(\frac{1}{q_i} \right) \right),$ where q_i is the market share of the i -th firm (expressed as a fraction), and n is the number of firms operating in the IT services market	Reflects the degree of uniformity in the distribution of market shares among all companies. Higher values indicate greater uniformity and competition	5.09
Variance of shares (σ^2)	$\sigma^2 = \frac{1}{n} \sum_{i=1}^n (q_i - \bar{q})^2,$ where q_i is the market share of the i -th firm (expressed as a fraction); $\bar{q}$ is the average market share of a single firm in the IT services market, calculated as $\frac{1}{n}$, n – the total number of firms operating in the market	Measures deviations of individual companies' market shares from the average share. High values indicate uneven distribution and potential concentration	0.0000356
Variance of logarithms ($\sigma^2_{\log}$)	$\sigma^2_{\log} = \frac{1}{n} \sum_{i=1}^n (\ln q_i - \ln \bar{q})^2,$ where q_i is the market share of the i -th firm (expressed as a fraction); $\bar{q}$ is the average market share of a single firm in the IT services market, calculated as $\frac{1}{n}$, n is the total number of firms operating in the market	Similar to the variance of shares, but applies logarithms to account for relative differences, making it more sensitive to disparities between small and large shares	0.7275
Gini index (G)	$G = \frac{1}{2(n-1)} \sum_{i=1}^n \sum_{j=1}^n y_i - y_j ,$ where y_i is the volume of services provided by the i -th firm, and y_j is the volume of services provided by the j -th firm	Reflects the degree of inequality in the distribution of market shares or sales volumes among companies in the IT services market, where a value of 0 indicates perfect equality, while a value close to 1 corresponds to maximum concentration of shares among a small number of companies. The indicator is calculated based on the Lorenz curve	0.601
Linda index (IL)	$IL = \frac{1}{k(k-1)} \sum_{i=1}^k q_i,$ where q_i is the market share of the i -th firm among the k largest firms (expressed as a fraction)	Reflects the degree of dominance of the largest companies ("market core") over the rest. Higher values indicate stronger dominance	169.2%

Source: calculated by the authors.

The Linda Index (IL = 169.2%) demonstrates the dominance of a limited number of companies in the market, particularly the four largest, which significantly surpass other participants in terms of market share. In the context of IT services, this indicates the formation of a market elite that concentrates the main orders, investments, and human capital. Such a market configuration requires differentiated regulation: on the one hand, supporting the innovative activity of market leaders, and on the other, stimulating the development of small and medium-sized businesses to prevent the strengthening of monopolistic tendencies.

The Gini Index (G = 0.601) reflects a high degree of inequality in the distribution of market shares, indicating a concentrated structure in the upper segment of the market. For the IT services market, this suggests the presence of a stable pool of leading companies that play a system-forming role by accumulating a significant share of total demand. On the one hand, such a configuration ensures stability and international competitiveness, while on the other, it creates potential entry barriers for new players.

The Lorenz curve based on 2024 data demonstrates a substantial deviation from the line of perfect equality, indicating significant concentration of market shares among leading companies. Specifically, a small group of firms accounts for a critically important segment of the market, while the majority hold relatively minor shares. This configuration confirms the conclusions drawn from numerical indices (in particular, the Gini and Linda indices) and visually illustrates the asymmetric market structure with elements of oligopolistic influence in the upper segment (Fig. 2).

The obtained quantitative indicators reveal a complex structure of the IT services market in Ukraine, which cannot be unequivocally classified under any of the classical

typologies of market structures. On the one hand, the high value of the Entropy Index (5.09) and the low variance of market shares ($\sigma^2 = 0.0000356$) indicate the presence of a significant number of active participants with a relatively even distribution of shares, which is typical for conditions of monopolistic competition. On the other hand, the Gini Index (0.601) and the Linda Index (169.2%) point to the pronounced dominance of a limited group of leading companies that form the "core" of the market and possess considerable market power. Such a configuration allows the market structure to be classified as hybrid, with prevailing features of diffuse competition alongside certain oligopolistic elements in the upper segment. This structural heterogeneity reflects the dynamic transformation of the market, where the steady growth of small and medium-sized IT companies coexists with the high concentration of market power among industry leaders.

We also analyzed the IT services market structure by business model type and found that in 2024, outsourcing companies dominated, accounting for 47% of the market. Product companies accounted for 31%, mixed models (combining elements of outsourcing and proprietary product development) represented 19%, while the least common type was outstaffing – only 3% (Fig. 2). This structure confirms that the export-oriented model (primarily outsourcing) remains dominant in the Ukrainian IT business, although the growing presence of product and hybrid companies indicates the market's evolution towards higher value-added activities.

Thus, the IT services market in Ukraine demonstrates not only quantitative growth after the decline of 2022–2023 but also retains a complex, multi-level corporate structure, in which a single business group may include several affiliated legal entities, requiring caution when analyzing market statistics.

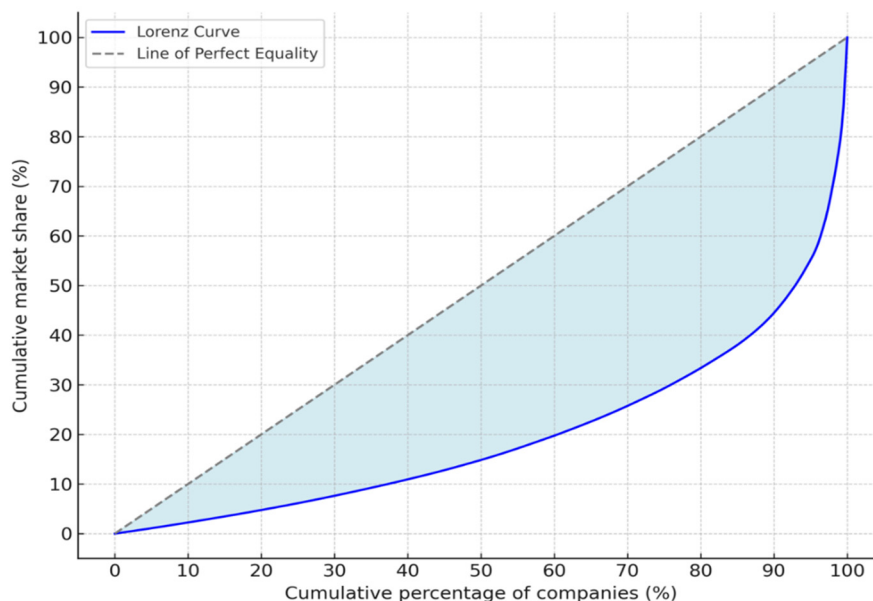


Fig. 2. Lorenz Curve (concentration) of the distribution of market shares of firms in the IT services market of Ukraine, 2024
Source: authors' own elaboration.

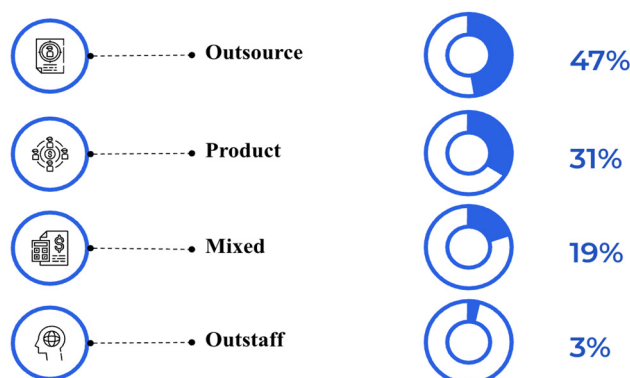


Fig. 3. Structure of the IT services market in Ukraine by business model type in 2024, %

Source: developed by the author based on Lviv IT Cluster data.

Finally, it should be noted that providing a comprehensive and reliable assessment of the degree of concentration and, consequently, competition in the Ukrainian IT services market based on traditional analytical methods is a rather challenging task. We agree with other authors that the main reasons for this include:

- some domestic IT companies are outsourcing providers fulfilling orders for international corporations and do not operate in the domestic market;
- most IT companies, although engaged in similar activities (which creates elements of competition), still differ in the specifics of their IT tasks and solutions offered (a manifestation of monopolistic tendencies).

Discussion and conclusions

Scientific research by both Ukrainian and international scholars devotes considerable attention to analyzing market concentration levels in high-tech sectors, particularly in IT services, as it directly influences competitiveness and corporate resilience. However, comprehensive studies evaluating the structure of Ukraine's IT services market during the wartime transformations of 2022–2024 remain scarce. This study partially addresses this gap, demonstrating that the domestic IT services market is undergoing structural transformation, combining elements of intense competition with the continued dominance of certain players.

In comparative perspective, these dynamics resonate with three major strands in the literature. First, the "superstar-firms" view links digital scale and intangibles to persistent concentration and higher markups (Autor et al., 2020; De Loecker, & Eeckhout, 2020; Bessen, 2020). Second, innovation theory suggests an inverted-U relationship in which moderate rivalry fosters "neck-and-neck" innovation while excessive concentration can dampen it (Aghion et al., 2005). Third, policy-institutional work argues that targeted SME digitalisation reduces entry and scaling frictions, sustaining competition even under shocks (OECD, 2024). Our wartime evidence provides a useful counterpoint to the first view while aligning with the latter two: rivalry appears to have broadened despite turbulence, yet a leading core persists.

The results of quantitative calculations (HHI, CR₃, CR₅, Gini Index, Linda Index) show that market concentration levels are gradually decreasing. This is reflected in the declining shares of the largest companies and the growing role of small and medium-sized enterprises (SMEs), whose share of total revenue increased from 52.7% in 2022 to 62.4% in 2024. Consequently, the market is becoming increasingly fragmented, reducing the risks of monopolization. At the same time, the Gini Index (0.601) and the Linda Index (169.2%) highlight the presence of a powerful core of companies that maintain a system-forming

role and capture a significant portion of demand. This indicates the emergence of a hybrid market structure combining features of monopolistic competition and oligopoly in the upper segment.

Viewed through theory, such a "hybrid" structure is consistent with the inverted-U intuition: broadened rivalry (lower HHI/CR_n) can coexist with an upper-tier core without collapsing into dominance (Aghion et al., 2005). Methodologically, using multiple indicators is warranted because HHI and CR_n capture top shares, whereas inequality-sensitive and entropy-type measures detect distributional tails and core-periphery contours (Kvålseth, 2018; Zhou, 2022). Benchmarked against antitrust thresholds, the observed HHI levels map to unconcentrated-moderate ranges in the U.S. Merger Guidelines/DOJ guidance, reinforcing the interpretation of reduced monopolization risks (U.S. Department of Justice & Federal Trade Commission, 2023; U.S. Department of Justice, Antitrust Division, 2024).

The growing share of SMEs can be interpreted as evidence of their adaptability and flexibility in the face of military and economic shocks. It also points to the capacity of smaller firms to create new niches, promote market diversification, and mitigate overall concentration risks. Meanwhile, the persistence of a stable core of large companies underscores the importance of maintaining balance: on the one hand, stimulating the development of small and medium players, and on the other, creating conditions for effective cooperation with market leaders to ensure integration into global value chains.

This balance aligns with the policy-institutional perspective that treats SME digitalisation as a resilience multiplier (OECD, 2024) and helps explain why, contrary to the superstar-dominance pattern seen elsewhere, Ukraine's IT services did not gravitate toward higher concentration during 2022–2024 (cf. Autor et al., 2020; De Loecker, & Eeckhout, 2020). At the same time, evidence of rising industry concentration in many mature economies (e.g., Grullon, Larkin, & Michaely, 2019) provides a useful external benchmark, highlighting the distinctiveness of Ukraine's wartime trajectory.

Overall, the Ukrainian IT services market demonstrates a strengthening competitive environment while maintaining structural asymmetry. This calls for an adaptive regulatory approach aimed at fostering further market diversification while ensuring the strategic resilience of the sector. Future research could focus on exploring correlations between market concentration levels and companies' financial stability, as well as analyzing the impact of business model types (outsourcing, product, or mixed) on the competitive balance within the sector. Policy priorities naturally follow: (i) institutionalise SME-oriented digitalisation and export-readiness programs; (ii) maintain transparent, methodologically documented monitoring of HHI/CR_n/Gini/Linda; and (iii) support cluster-based cooperation between SMEs and core firms to accelerate capability transfer without entrenching dominance (OECD, 2024; U.S. Department of Justice & Federal Trade Commission, 2023; U.S. Department of Justice, Antitrust Division, 2024). Future research could focus on exploring correlations between market concentration levels and companies' financial stability, as well as analyzing the impact of business model types (outsourcing, product, or

mixed) on the competitive balance within the sector. Robustness tests should also assess sensitivity to group consolidation rules and tail treatments, given known measurement caveats (Kvålseth, 2018; Zhou, 2022).

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ОЦІНЮВАННЯ КОНКУРЕНТНОГО СЕРЕДОВИЩА ІТ-КОМПАНІЙ

Вступ. Ринок ІТ-послуг України залишається одним із найбільш динамічних та експортно орієнтованих сегментів економіки навіть під час повномасштабної війни, проте одночасно зазнає процесів консолідації, виходу компаній із ринку, злиття і поглинань, а також реструктуризації. Малі та середні підприємства (МСП) відіграють дедалі помітнішу роль, водночас конкурентні умови залишаються неоднозначними, оскільки бізнес-групи можуть містити кілька пов'язаних юридичних осіб. Об'єктом дослідження є ринок ІТ-послуг України, предметом – конкурентне середовище та структурні асиметрії ринку у 2022–2024 рр. Метою цього дослідження є оцінювання рівня та динаміки конкуренції шляхом вимірювання ринкової концентрації та структурних асиметрій у 2022–2024 рр.

Методи. Застосовано системно-структурний підхід із використанням показників концентрації для підприємств, класифікованих за секціями КВЕД 62 і 63. До індикаторів належать індекс Герфіндаля – Гіршмана (ННІ), коефіцієнти концентрації (CR_3 , CR_5), індекс Джині, індекс ентропії, індекс Лінда та дисперсійні показники. Ринкові частки розраховано на основі виручки; додатково оцінено частку МСП у загальній виручці ринку. Описову статистику доповнено порівняльним аналізом за 2022–2024 рр. на вибірці з 411 компаній (з них 13 великих), з урахуванням розриву між кількістю юридичних осіб і кількістю верифікованих активних компаній.

Результати. Ринок характеризується складною корпоративною структурою: у 2024 р. ІТ-послуги надавали 8,6 тис. юридичних осіб, проте лише 2 118 компаній було верифіковано як активні. Індекс ННІ знизився з 433,68 (2022) до 170,86 (2024), що свідчить про посилення конкуренції. Показник CR_3 скоротився з 26,18 % до 17,77 %, а CR_5 – з 34,13 % до 23,31 %; частка МСП у виручці зросла з 52,7 % до 62,4 %. Чутливі до розподілу показники виявляють гібридну структуру: висока ентропія ($E = 5,09$) та низька дисперсія свідчать про широку участь компаній, тоді як індекс Джині (0,601), індекс Лінда (169,2 %) і крива Лоренца вказують на домінуюче ядро у верхньому сегменті ринку. За типом бізнес-моделі 2024 р. переважають аутсорсингові компанії (47 %), далі йдуть продуктові (31 %), змішані (19 %) та аутстафінгові (3 %).

Висновки. Ринок ІТ-послуг України поступово набуває більш конкурентної та децентралізованої структури, хоча олігополістичне ядро зберігається. Зростання ролі МСП та зменшення часток провідних компаній знижують ризики монополізації, підвищують стійкість ринку та створюють передумови для розвитку сегментів із більшою доданою вартістю. Регуляторна політика має забезпечити баланс між підтримкою входження та масштабування МСП і створенням умов для ефективної кооперації з ринковими лідерами задля інтеграції у глобальні ланцюги вартості. Запропоновану методологію можна застосувати й до інших високотехнологічних ринків, тоді як подальші дослідження можуть бути зосереджені на аналізі взаємозв'язку між динамікою концентрації, фінансовою стійкістю компаній і впливом типу бізнес-моделі на конкурентний баланс у секторі.

Ключові слова: ринок ІТ-послуг, структурна асиметрія ринків, конкуренція, олігополістичне ядро ринку, концентрація ринків.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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ASSESSMENT OF THE PRIORITY OF SUSTAINABLE DEVELOPMENT GOALS IN THE CONTEXT OF CURRENT CHALLENGES FOR UKRAINE

Background. The global coronavirus pandemic, combined with economic, social, and environmental challenges during a full-scale invasion, has had a profoundly negative impact on the system of interaction among businesses, consumers, partners, and stakeholders. The modern business landscape requires coordinated actions by the global community to establish balance in the domestic business ecosystem, interacting with international donors and potential investors. A full-scale invasion is a catalyst for the sustainability of domestic businesses. It is the ability to ensure economic survival while simultaneously preserving social responsibility and the environmental interests of natural ecosystems. The goal of the study is to develop an algorithm for conducting a comprehensive assessment of the priority of sustainable development goals. We substantiate a methodological support. According to this approach, we group the goals by economic, environmental, and social indicators, generalizing the criteria for their selection in different periods (before and during the war), and identifying the changes that have occurred.

Methods. One of the objectives of the study is to determine the priority of implementing sustainable development goals in different periods (before the war and during the war) and identify the changes that occurred. Solving the problem of determining the priority of implementing these goals at a practical level can be reduced to their ranking within each component using multi-criteria analysis methods. They are widely represented in management theory and practice. To solve the research tasks, we use methods for evaluating alternatives. They are TOPSIS, SAW, COPRAS.

Results. The modern challenges that Ukraine faces today have somewhat changed the priority of implementing sustainable development goals across all components of sustainable development: by the economic component, "peace and justice" and "partnership for sustainable development" are becoming relevant for Ukraine; by the social component, the goals of "decent work and economic growth" and "quality education" are the first; by the environmental component, the goals of "affordable and clean energy" and "clean water and adequate sanitation" became prioritized.

Conclusions. The war in Ukraine has brought to the fore the issue of theoretical discourse around the priority of sustainable development components for our state. But the war did not change the desire of entrepreneurs to solve their economic problems, taking into account the development of the concept of sustainable development, solving social issues, and respecting the environmental interests of society.

Keywords: the goals of sustainable development, multi-criteria analysis methods, economic component of sustainable development, social component of sustainable development, environmental component of sustainable development, the priority of sustainable development goals.

Background

Relevance of the research. Nowadays, the effective operation and success of any organization in the market depends on understanding and adhering to the principles of sustainable development in its activities. The United Nations has identified 17 Sustainable Development Goals and 169 targets by the year 2030. They are the focus of organizations from all countries and sectors that adhere to the declared Sustainable Development Goals.

The global coronavirus pandemic, combined with economic, social, and environmental challenges during a full-scale invasion, has had a profoundly negative impact on the system of interaction among businesses, consumers, partners, and stakeholders. The modern business landscape requires coordinated actions by the global community to establish balance in the domestic business ecosystem, interacting with international donors and potential investors. A full-scale invasion is a catalyst for the sustainability of domestic businesses. It is the ability to ensure economic survival while simultaneously preserving social responsibility and the environmental interests of natural ecosystems.

Currently, domestic businesses are showing increasing interest in the ESG concept. ESG means: E – environment, S – social responsibility, G – governance. The implementation of this concept requires comprehensive efforts of the company to achieve long-term sustainable development goals. The ESG concept grows into a roadmap for companies to implement sustainable development programs and to develop individual strategies. In them, each component may be represented to a greater or lesser extent depending on the business activity and involves complex efforts to achieve the set sustainable development goals. Business compliance with international standards at the level of ESG mastery allows Ukraine to participate in global investment projects while the economy recovers.

Therefore, sustainable development is a concept that can solve the complex socio-ecological and economic problems during the war. We can assess the sustainability of organizations by the results of their activities in three areas. They are economic, social, and environmental spheres.

The sustainable development paradigm organically combines the economic interests of business entities with the

social problems of humanity and the environmental interests of the survival of human civilization. The war has made the issue of the functioning of natural ecosystems relevant for both entrepreneurs and all citizens. Therefore, the theoretical discourse of sustainable development acquires new aspects due to military actions on the territory of our state.

The goal and objectives of the study are to develop an algorithm for conducting a comprehensive assessment of the priority of sustainable development goals. We substantiate a methodological support. According to this approach, we group the goals by economic, environmental, and social indicators, generalizing the criteria for their selection in different periods (before and during the war), and identifying the changes that have occurred.

The object of research is the Sustainable Development Goals (SDG). They are the basis for managing a modern enterprise. The focus is on prioritizing sustainable development goals. In particular, the authors analyze the change in priorities under the influence of modern challenges.

Literature review. The prerequisites for the formation and development of conceptual provisions for sustainable development have been laid over the past fifty years. The main steps taken by politicians and economists at United Nations Conferences, Special Sessions of the United Nations General Assembly, and World Summits. Table 1 presents the Genesis of the conceptual provisions of sustainable development formation during the twentieth century, recorded in UN documents.

Table 1

The Genesis of the conceptual provisions of sustainable development formation in the twentieth century

A significant stage	Main achievements of the stage of the sustainable development concept formation
5–6.06.1972, Stockholm, United Nations Conference on the Human Environment	The Declaration of the UN Conference on the Human Environment, with 26 principles, was adopted (Stockholm Declaration, 1972). An Action Plan for the Protection of the Human Environment was adopted. General approaches to creating the United Nations Environment Programme were announced. Environmental issues were brought to the forefront of international concerns. A dialogue was between industrialized and developing countries on the link between economic growth, pollution of the air, water, and oceans, and the well-being of people around the world. The conference recognized the human right to "freedom, equality and adequate living conditions in the environment". The United Nations Environment Programme (UNEP) was established following the Stockholm Conference. It is a UN body. Its mission is to monitor environmental conditions, inform policymakers about scientific progress, and stimulate international cooperation. In honor of the conference, June 5 is World Environment Day.
3–14.06.1992, Rio de Janeiro, United Nations Conference on Environment and Development (UNCED). It is also known as the Earth Summit.	The Earth Summit's goal was to develop a wide-ranging agenda and a new plan for international action on the environment and development that could help to guide international cooperation and development policy in the 21st century. The conference adopted a 27-point Declaration on the Environment and Development, committing states to the principles of sustainable development. It was proposed that states develop a national sustainable development strategy (SDS) in accordance with their specificities, priorities, environmental and economic situation, and the state of development of their national economies. Agenda 21 was adopted by governments as a program of action to implement the concept of global sustainable development. A Declaration of Principles of the Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests was also adopted. Two major global agreements are open for signature: the Framework Convention on Climate Change and the Convention on Biological Diversity. It was in Rio de Janeiro that the problems of global warming and the preservation of Earth's biodiversity received worldwide political recognition.
June 1997, New York, Special Session of the UN General Assembly to Review and Appraise the Implementation	The 19th special session of the UN General Assembly was dedicated to a five-year review of progress in achieving the 21st-century Agenda. The conference concluded that positive developments were not enough to achieve the goals set in 1997, and the main problems remain relevant. They invited countries to develop their own sustainable development strategies by 2002.
06.09.2000, New York, UN Global Compact. It is a special initiative of UN Secretary-General Kofi Annan	189 states, UN members, adopted the Millennium Declaration at this summit. It sets out eight Millennium Development Goals (MDGs): 1) to eradicate extreme poverty and hunger; 2) to achieve universal primary education; 3) to promote gender equality and women's empowerment; 4) to reduce child mortality; 5) to improve the mother's health; 6) to combat HIV, AIDS, malaria, and other diseases; 7) to ensure environmental sustainability; 8) to establish a global partnership for development. The 10 principles, based on the UN Global Compact, for socially and environmentally responsible business, were adopted. They reflect standards in the areas of human rights, labor relations, environmental protection, and anti-corruption.

Source: compiled by the authors based on (UN. General Assembly, 1992, June; UN Documents, 1972; UN Documents, 1973; UN Documents, 1987; UN. General Assembly, 1992, December; UN. General Assembly, 2016, December).

Table 2 presents the Genesis of the deployment of the sustainable development paradigm according to institutional provisions. They have been proclaimed by the United

Nations at Conferences, Special Sessions of the United Nations General Assembly, World Summits, and special events in the twenty-first century.

Table 2

The Genesis of the Concept of Sustainable Development Deployment in the 21st Century

A significant stage	Main achievements of the stage of the sustainable development concept formation
26.08–04.09.2002, Johannesburg World Summit on Sustainable Development	The World Summit demonstrated that not all countries were able to develop and adopt a national sustainable development strategy. Therefore, the Political Declaration and Implementation Plan were adopted. The Implementation Plan included: – provisions covering a set of measures that countries need to take to achieve development, taking into account the needs of the environment; – taking into account the provisions of the Kyoto Protocol on reducing greenhouse gas emissions for those countries that have ratified it; – creating a global solidarity fund to eradicate poverty; – launching ten-year programs to support regional and national initiatives aimed at accelerating the transition to sustainable production and consumption models.
14–16.09.2005, New York, UN World Summit	Government commitments to achieve development goals by 2015. The final document states that "each state is responsible for protecting its population from genocide, war crimes, ethnic cleansing, and crimes against humanity."
22–25.09.2008, New York, High-level meeting dedicated to the Millennium Development Goals	This is a high-level meeting. The UN Secretary-General and the Chair of the General Assembly at UN Headquarters organized this meeting on achieving the MDGs organized this meeting. It was a platform for international leaders to announce specific plans, proposals, and actions to find the necessary resources and mechanisms to address the identified gaps in achieving the MDGs. The meeting helped accelerate the implementation and monitoring of the MDGs.
20–22.09.2010, New York, Millennium Development Goals Summit	Summit participants adopted the Global Action Plan "Keeping the Promise: United Efforts to Achieve the Millennium Development Goals". Initiatives aimed at combating poverty, hunger, and disease have been announced. The Global Strategy for Women's and Children's Health was launched.
20–22.07.2012, Rio de Janeiro, United Nations Conference on Sustainable Development	The process of developing Sustainable Development Goals, which are based on the MDGs, has begun. A ten-year framework for sustainable consumption and production models' programs has been accepted. Innovative guiding principles for green economy policy have been adopted. A sustainable development financing strategy has been implemented.
25.09.2013, New York, Special event of the President of the UN General Assembly on achieving the Millennium Development Goals	Member States reaffirmed their commitment to achieving the Millennium Development Goals. They agreed to convene a High-Level Summit in 2015. They plan to adopt a new set of goals there. They will build on the foundations laid in the MDGs and on future challenges. The new goals will aim to balance the three elements of sustainable development: – to provide transformation and the opportunity to lift people out of poverty; – to promote social justice; – to protect the environment.
25–27.09.2015, New York, United Nations Conference on Sustainable Development	New sustainable development plan officially approved. It is "Transforming Our World: The 2030 Agenda for Sustainable Development". It contains a declaration, 17 goals of sustainable development, and 169 targets. The purposes of the plan are: – to find new ways to improve the lives of people around the world; – to eradicate poverty; – to promote prosperity and well-being for all; – to protect the environment; – to fight climate change.
June 2022, Stockholm, International environmental meeting under the auspices of the UN Conference	It is the international ecological meeting. Its topic is "Stockholm+50: a healthy planet for shared prosperity is our responsibility, our opportunity". It was prepared in March 2022 at the United Nations Headquarters in New York. The UN Secretary-General, Antonio Guterres, noted the following. Fifty years ago, humanity recognized its collective responsibility to protect nature and, for the first time, acknowledged it as a prerequisite for peace, prosperity, and development. Member States have the primary responsibility for ensuring sustainable development at national, regional, and local levels. It involves taking steps to integrate the SDGs into national policies and allocating resources to support their achievement. Member States regularly report on their progress towards achieving the SDGs through relevant Voluntary National Reviews. Post-COVID-19 update plans are separately defined.
03.07.2025, Seville, The 4th International Conference on Financing the Sustainable Development Goals	The Seville Agreement became the first intergovernmental agreement since 2015 on financing in such areas: – attracting investments in sustainable development; – solving debt and financing crises in low- and middle-income countries; – deep reform of the international financial system. The International Business Forum and the SDG Investment Fair held within the conference contributed to concrete steps to reduce the SDG financing gap.

Source: compiled by the authors.

From Table 2, we can see that at the Special Event of the UN General Assembly Chief on the Millennium Development Goals in September 2013, in New York, Member States reaffirmed their commitment to achieving the Millennium Development Goals. They agreed to convene a High-Level Summit in 2015. Its purpose is to adopt a new set of goals. Their base is the foundations laid in the MDGs and future challenges. The new goals aim to balance the three elements of sustainable development: providing transformation and the opportunity to lift people

out of poverty; promoting social justice; protecting the environment. That is, they divided the future Sustainable Development Goals into three components: economic, social, and environmental.

In Ukraine, the Sustainable Development Goals are integrated into state policy for the period until 2030. They are the recorded in the Decree of the President of Ukraine (Supreme Council of Ukraine, 2019).

During the national consultations, 17 SDGs were discussed by groups. They are: sustainable economic

growth and employment; equitable social development; effective, accountable and inclusive governance and justice for all; ecological balance and building resilience (Ministry of Economic Development and Trade of Ukraine, 2017).

Currently, the global scientific community has recognized the need to provide theoretical, methodological, and practical foundations for the development of economic, ecological, and social ecosystems. Thus, the works (Hák, Janoušková, & Moldan, 2016; Shmorgun, 2022; Kravchenko, & Prudkyiy, 2020; Zatonatska et al., 2025) focus on the need to achieve a balance between the three components of sustainable development: economic, social, and environmental.

In the scientific literature, the issues of research by scientists towards achieving sustainable development goals are devoted to revealing the following aspects:

- Achieving the Sustainable Development Goals by taking urgent action to combat climate change and its impacts. In particular, the authors propose to use nature-based solutions in decision-making. This study uses the results of scientific publications in the scientometric databases Scopus and WoS. Among the analytical methods used in this study, it is worth highlighting the Shapiro-Francia W test and the two-sample Mann-Whitney U-test (Okolie et al., 2025).

- Assessment of material, technical, financial, and organizational support for achieving the goals of sustainable development. The authors analyze challenges that countries face in implementing the Sustainable Development Goals. This study aims to identify and assess how governments, non-governmental organizations, and universities perceive, promote, and manage issues related to achieving the Sustainable Development Goals. To achieve the goal, the authors implement the following actions: carry out a bibliometric analysis; assess the level of implementation of the Sustainable Development Goals and the impact of COVID-2019 on this process; identify the need for investment, technology and infrastructure to achieve sustainable development goals; identify key obstacles along this way; conduct a systematic analysis of 11 separate case studies to triangulate a holistic analysis (Filho et al., 2022).

- Disproportions and trajectories of countries' development in achieving sustainable development goals. The authors analyze the specialization of different countries in achieving sustainable development goals. The Sustainable Development Goals indicators, both environmentally and non-environmentally related, are presented, ranked by the Sustainable Development Goals Index and their correspondence to the Sustainable Development Goals taxonomies of the United Nations Statistical Distribution. (Ma et al., 2025).

Publications related to the implementation of the concept of sustainable development in Ukraine mainly focus on the analysis of economic and statistical indicators. They characterize the state of key sectors of the national economy and their capabilities for the implementation and realization of sustainable development goals (Zamula, Shavurska, & Kireitseva, 2024). The article (Stukalo et al., 2021) analyzes changes in the structure of global threats to the sustainable development of Ukraine under the influence of the global crisis and the COVID-2019 pandemic.

The study is based on the analysis of the components of integrated indicators. Formed on this basis, indicators are used to assess the state of balance in the socio-economic development of the national economy and to determine the directions of corrective policy.

An analysis of scientific publications by both foreign and domestic scientists shows that assessing the priority of sustainable development goals in Ukraine at this stage of development is relevant. It will provide the opportunity to form a scientific and methodological support for the development of the domestic economy during wartime and in the post-war period.

Methods

The conditions of modern challenges for Ukraine have been reflected in the issues of importance and priority of implementing the identified sustainable development goals. Therefore, one of the objectives of the study is to determine the priority of implementing sustainable development goals in different periods (before the war and during the war) and identify the changes that occurred. Solving the problem of determining the priority of implementing these goals at a practical level can be reduced to their ranking within each component using multi-criteria analysis methods. They are widely represented in management theory and practice. To solve the research tasks, we use methods for evaluating alternatives. They are TOPSIS, SAW, COPRAS. They differ from each other in the algorithm for determining the optimal order of alternatives.

Simple Additive Weighting Method (SAW) (MacCrimmon, 1968) is one of the oldest. It allows, in practice, to determine the effectiveness of choosing alternatives using simple additive weighting.

TOPSIS (The Technique for Order Preference by Similarity to the Ideal Solution) (Hwang, & Yoon, 1981) has proven its ability to solve socio-economic problems over the past decades.

COPRAS (Complex Proportional Assessment) (Zavadskas, & Kaklauskas, 1996) is a method of complex proportional evaluation. It allows for multi-criteria assessment of alternatives by both maximizing and minimizing the values of the criteria.

Results

The generally accepted is three-component structure of the concept of sustainable development. Within the framework of the study, we consider that the sustainable development goals highlighted in the "National Report "Sustainable Development Goals: Ukraine" (Sustainable Development Goals: Ukraine, 2017) should be divided into three groups. They are economic, social and environmental.

Based on this assumption, the 17 global sustainable development goals would be grouped as follows:

1. Economic component:

- EC1 – industry, innovations and infrastructure;
- EC2 – reducing inequality;
- EC3 – sustainable development of cities and communities;
- EC4 – responsible consumption and production;
- EC5 – peace and justice;
- EC6 – partnership for sustainable development.

2. Social component:

- SC1 – poverty alleviation;
- SC2 – overcoming hunger;
- SC3 – strong health;
- SC4 – quality education;
- SC5 – gender equality;
- SC6 – decent work and economic growth.

3. Environmental component:

- EnC1 – clean water and proper sanitation;
- EnC2 – affordable and clean energy;
- EnC3 – climate change mitigation;
- EnC4 – conservation of marine resources;
- EnC5 – preservation of terrestrial ecosystems.

To substantiate the decision-making concerning prioritizing sustainable development goals (which will be seen as alternatives) within individual groups, it is necessary to determine the criteria for their selection. In the process of directly selecting alternatives, each expert independently chooses one or another combination of criteria. The difficulty of the decision lies in what criteria to give preference to. Today, there is no single set of criteria that can be applied to solve this problem. Within the framework of our study, we selected the following criteria:

- **K1** – the ability to predict the results of goal implementation;
- **K2** – the probability of successful implementation of the goal;
- **K3** – the level of relevance of the goal;
- **K4** – the level of goal flexibility;
- **K5** – the level of difficulty in achieving the goal;
- **K6** – the projected level of costs for the development and implementation of the goal;
- **K7** – the expected duration of goal development and implementation.

In the proposed list, the first four criteria (K1-K4) have a function that tends to *max*, and the remaining three criteria (K5-K7) tend to *min*.

When implementing the task of prioritizing sustainable development goals, the above criteria have different weights. To solve this problem, we formed a group of 7 experts. The respondents are the speakers and participants of the advanced training program "Forming a sustainable bioeconomy in the face of modern challenges in Ukraine". It is implemented within the framework of the project 101127252 – ERASMUS-JMO-2023-HEI-TCH-RSCH Jean Monet direction "Promotion of European skills and approaches for sustainable bioeconomy in the conditions of Ukrainian acute challenges" (PESAB). The experts carried out the determination of weighting coefficients using the method of direct assessment of criteria on the following scale:

- **0** – no need to demonstrate the criterion;
- **1** – the need for a minimum manifestation of the criterion;
- **2** – the need for an average manifestation of the criterion;
- **3** – the need for a high manifestation of the criterion.

The results of the experts' evaluation of the criteria and the determination of their weighting coefficients are given in Table 3. Similar calculations were carried out to determine the weight of individual components for all attributes (Table 6).

Table 3

Weighting factors of selection criteria for determining the priority of sustainable development goals by components

Criteria	Expert							Total points	Weighting factor
	1	2	3	4	5	6	7		
K1	2	2	3	3	2	2	2	16	0.130
K2	2	2	3	3	3	2	2	17	0.138
K3	3	3	3	3	3	3	3	21	0.172
K4	2	2	3	2	3	3	2	17	0.138
K5	2	3	3	3	2	2	3	18	0.146
K6	3	3	2	3	2	2	3	18	0.146
K7	2	2	2	3	2	3	2	16	0.130
Σ								123	1

Source: developed by the authors.

The next stage of the study is to evaluate and rank the sustainable development goals by components. To assess the criteria, we asked the experts to use the basic scale of C. Osgood. It is a discrete scale on which the respondent can assess their attitude towards the object being studied using a 5-dimensional scale of ratings between two bipolar statements: 1 – the worst rating, 5 – the best (Osgood, 1953).

To rank the sustainable development goals by economic component, we propose to use the method TOPSIS.

The substantiation of the goals ranking is carried out in several stages:

1. Conducting an assessment of goals based on the economic component according to pre-defined criteria. It is assumed that each criterion of the decision matrix has either a monotonically increasing or a monotonically decreasing objective function. The constructed decision matrix $X = ||X_{ij}||$

(the values of all criteria belong to the Edgeworth-Pareto set) is presented in Tables 4, 5.

2. Carrying out normalization of the decision matrix. At this stage, criteria that have different units of measurement are transformed into dimensionless criteria. This allows for their further comparison.

Since within our study all criteria have the same units of measurement (evaluated on a 5-point scale), this stage can be skipped.

3. Construction of a weighted normalized decision matrix (Tables 6, 7). In this case, the weights of the criteria determined at the previous stage of the study are applied.

4. Determining the ideal positive and ideal negative solution by searching for two artificial alternatives EC^+ та EC^- (Table 8).

Table 4

Initial data (decision matrix) for ranking sustainable development goals by economic component using TOPSIS method in pre-war conditions

Function	Expert ratings						
	K1	K2	K3	K4	K5	K6	K7
	max	max	max	max	min	min	min
EC1	4.143	3.857	3.429	4.286	3.000	3.286	3.429
EC2	4.286	4.571	3.857	3.286	2.429	2.571	2.714
EC3	4.714	4.571	4.571	4.143	4.143	3.857	2.571
EC4	4.571	4.571	3.429	4.286	2.714	3.857	3.286
EC5	4.571	4.286	4.571	4.571	2.714	3.429	2.286
EC6	4.286	4.143	4.571	3.857	3.429	2.714	2.429

Source: developed by the authors.

Table 5

Initial data (decision matrix) for ranking sustainable development goals by economic component using TOPSIS method under martial law

Function	Expert ratings						
	K1	K 2	K 3	K 4	K 5	K 6	K 7
Function	max	max	max	max	min	min	min
EC1	2.857	3.714	2.857	2.285	4.285	4.429	4.571
EC2	2.285	2.571	3.285	2.285	4.714	4.285	4.429
EC3	3.714	2.857	3.285	2.857	4.571	4.429	3.429
EC4	2.571	2.857	3.714	4.143	4.429	4.285	3.714
EC5	4.143	4.571	4.714	4.143	4.285	3.429	2.857
EC6	2.285	3.285	4.571	3.714	4.571	4.714	4.429

Source: developed by the authors.

Table 6

Weighted normalized decision matrix in pre-war conditions

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
EC1	0.539	0.532	0.590	0.591	0.438	0.480	0.446
EC2	0.557	0.631	0.663	0.453	0.355	0.375	0.353
EC3	0.613	0.631	0.786	0.572	0.605	0.563	0.334
EC4	0.594	0.631	0.590	0.591	0.396	0.563	0.427
EC5	0.594	0.591	0.786	0.631	0.396	0.501	0.297
EC6	0.557	0.572	0.786	0.532	0.501	0.396	0.316

Source: developed by the authors.

Table 7

Weighted normalized decision matrix under martial law

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
EC1	0.371	0.513	0.491	0.315	0.626	0.647	0.594
EC2	0.297	0.355	0.565	0.315	0.688	0.626	0.576
EC3	0.483	0.394	0.565	0.394	0.667	0.647	0.446
EC4	0.334	0.394	0.639	0.572	0.647	0.626	0.483
EC5	0.539	0.631	0.811	0.572	0.626	0.501	0.371
EC6	0.297	0.453	0.786	0.513	0.667	0.688	0.576

Source: developed by the authors

Table 8

Perfectly positive and perfectly negative matrix solutions (artificial alternatives)

In pre-war conditions							
Artificial alternatives	max u ₁	max u ₂	max u ₃	max u ₄	min u ₅	min u ₆	min u ₇
EC ⁺ EC ⁺ (perfectly positive)	0.613	0.631	0.786	0.631	0.605	0.563	0.446
EC ⁻ EC ⁻ (perfectly negative)	0.539	0.532	0.590	0.453	0.355	0.375	0.297
Under martial law							
Artificial alternatives	max u ₁	max u ₂	max u ₃	max u ₄	min u ₅	min u ₆	min u ₇
EC ⁺ EC ⁺ (perfectly positive)	0.539	0.631	0.811	0.572	0.688	0.688	0.594
EC ⁻ EC ⁻ (perfectly negative)	0.297	0.355	0.491	0.315	0.626	0.501	0.371

Source: developed by the authors.

5. Ranking of sustainable development goals by economic component by calculating the degree of proximity. The distance from one alternative to another can be calculated using formulas that define the n-dimensional Euclidean distance:

$$S_i^+ = \sqrt{\sum_{j=1}^m (u_{ij} - u_j^+)^2},$$

$$S_i^- = \sqrt{\sum_{j=1}^m (u_{ij} - u_j^-)^2}.$$

Calculating the relative proximity to the "ideal solution". The alternative EC is closer to EC* the closer C is to 1 (Table 9).

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}, \quad 0 < C_i^* < 1.$$

The comparative ranking of sustainable development goals by economic component in the pre-war period and during the war is presented in Table 10.

The modern challenges that Ukraine faces today change the priority of implementing sustainable development goals in terms of the economic component. More relevant for Ukraine are "peace and justice" and "partnership for sustainable development". In the pre-war period, the highest priority was "sustainable development of cities and regions".

To assess and rank the goals of sustainable development by social component, we use the multi-criteria analysis method SAW.

The use of the method implies the following actions:

1. Conducting an assessment of the sustainable development goals by the social component according to pre-defined criteria. The values of the evaluation criteria for each objective, as well as the corresponding constraints, are presented in Tables 11,12. The values of all criteria given in the table belong to the Edgeworth-Pareto set.

2. Normalization of the decision matrix for ease of use of the results of evaluating alternatives of strategic directions according to criteria.

Since within our study all criteria have the same units of measurement (evaluated on a 5-point scale), this stage can be skipped.

3. Obtaining a weighted normalized decision matrix (Tables 13, 14).

4. Determining the ranking of alternatives by calculating the weighted sum of scores for each alternative across all criteria. In this case, the alternative that has the highest value of the weighted sum of the estimates is considered the best. Based on the calculated weighted sums of scores for each alternative across all criteria, the following ranking of alternatives is formed (Table 15).

Table 9

Ranking of sustainable development goals by economic component

<i>In pre-war conditions</i>				
Alternatives	S_i^+	S_i^-	$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}$	Rank
EC1	0.300	0.243	0.448	5
EC2	0.396	0.136	0.256	6
EC3	0.127	0.409	0.764	1
EC4	0.291	0.293	0.502	3
EC5	0.268	0.307	0.534	2
EC6	0.268	0.262	0.494	4
<i>Under martial law</i>				
Alternatives	S_i^+	S_i^-	$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}$	Rank
EC1	0.465	0.319	0.407	4
EC2	0.515	0.259	0.334	6
EC3	0.419	0.277	0.398	5
EC4	0.382	0.346	0.475	3
EC5	0.298	0.551	0.649	1
EC6	0.308	0.463	0.600	2

Source: developed by the authors.

Table 10

The comparative ranking of sustainable development goals by economic component

	EC1	EC2	EC3	EC4	EC5	EC6
<i>In pre-war conditions</i>	5	6	1	3	2	4
<i>Under martial law</i>	4	6	5	3	1	2

Source: developed by the authors.

Table 11

Initial data (decision matrix) for ranking the sustainable development goals according to the social component using the SAW method *in the pre-war situation*

Function	Expert ratings						
	K1 max	K2 max	K3 max	K4 max	K5 min	K6 min	K7 min
SC1	4.714	3.857	4.714	4.571	3.429	3.429	2.429
SC2	3.857	4.143	4.286	4.571	3.286	3.000	2.714
SC3	4.714	4.000	3.286	4.286	2.714	2.571	2.429
SC4	4.143	3.857	4.714	4.286	3.429	3.286	2.571
SC5	4.571	4.143	4.571	3.857	3.000	2.857	2.286
SC6	4.286	4.714	3.286	4.143	2.714	3.286	2.857

Source: developed by the authors.

Table 12

Initial data (decision matrix) for ranking the sustainable development goals according to the social component using the SAW method *under martial law*

Function	Expert ratings						
	K1 max	K2 max	K3 max	K4 max	K5 min	K6 min	K7 min
SC1	3.000	2.429	4.286	3.429	4.857	4.286	4.143
SC2	3.714	2.571	3.714	4.143	2.714	3.714	3.857
SC3	3.429	3.857	4.143	3.714	3.714	4.571	4.000
SC4	2.714	2.571	4.857	4.143	4.286	4.571	4.286
SC5	2.429	2.857	4.143	3.714	3.857	4.286	3.429
SC6	3.429	3.000	4.571	4.143	4.286	3.714	4.571

Source: developed by the authors.

Table 13

Weighted normalized decision matrix (in the pre-war situation)

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
SC1	0.613	0.532	0.811	0.631	0.501	0.501	0.316
SC2	0.501	0.572	0.737	0.631	0.480	0.438	0.353
SC3	0.613	0.552	0.565	0.591	0.396	0.375	0.316
SC4	0.539	0.532	0.811	0.591	0.501	0.480	0.334
SC5	0.594	0.572	0.786	0.532	0.438	0.417	0.297
SC6	0.557	0.651	0.565	0.572	0.396	0.480	0.371

Source: developed by the authors.

Table 14

Weighted normalized decision matrix (under martial law)

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
SC1	0.390	0.335	0.737	0.473	0.709	0.626	0.539
SC2	0.483	0.355	0.639	0.572	0.396	0.542	0.501
SC3	0.446	0.532	0.713	0.513	0.542	0.667	0.520
SC4	0.353	0.355	0.835	0.572	0.626	0.667	0.557
SC5	0.316	0.394	0.713	0.513	0.563	0.626	0.446
SC6	0.446	0.414	0.786	0.572	0.626	0.542	0.594

Source: developed by the authors.

Table 15

Ranking of sustainable development goals by social component

Alternative	In the pre-war situation		Under martial law	
	Weighted sum	Rank	Weighted sum	Rank
SC1	3.905	1	3.809	4
SC2	3.712	3	3.488	6
SC3	3.408	6	3.933	3
SC4	3.788	2	3.965	2
SC5	3.636	4	3.571	5
SC6	3.592	5	3.980	1

Source: developed by the authors.

Both in the pre-war period and in wartime, all goals by of the social component are practically equivalent. Modern challenges for Ukraine have somewhat affected the priority structure of implementing sustainable development goals in this component. In modern conditions, the goals of "decent work and economic growth" and "quality education" have come to the fore. They are the basis for the further post-war reconstruction of Ukraine.

At the stage of evaluating and ranking sustainable development goals by environmental component, we propose the use of the method COPRAS:

1. Conducting an assessment of sustainable development goals by environmental component according to pre-defined criteria (Tables 16, 17). The value of the criteria belongs to the Edgeworth-Pareto set.

Table 16

Input data (decision matrix) for ranking sustainable development goals by the environmental component using the COPRAS method in the pre-war situation

Function	Expert ratings						
	K1	K 2	K 3	K 4	K 5	K 6	K 7
EnC1	max	max	max	max	min	min	min
EnC2	2.571	2.286	4.143	3.429	4.000	4.571	3.714
EnC3	2.429	2.571	4.714	3.286	4.143	4.429	3.857
EnC4	3.857	4.571	3.714	3.857	3.000	4.143	2.571
EnC5	3.000	4.143	2.571	3.429	3.429	3.286	3.429
EnC6	3.857	4.571	3.857	3.714	3.286	4.286	2.429

Source: developed by the authors.

Table 17

Input data (decision matrix) for ranking sustainable development goals by the environmental component using COPRAS method under martial law

Function	Expert ratings						
	K1	K 2	K 3	K 4	K 5	K 6	K 7
EnC1	max	max	max	max	min	min	min
EnC2	4.000	4.286	3.286	3.286	4.429	3.714	2.286
EnC3	4.143	4.571	3.857	4.714	3.286	3.000	2.571
EnC4	3.714	4.429	3.857	4.286	3.429	3.286	2.571
EnC5	3.286	4.000	4.143	4.143	4.571	4.429	2.714
EnC6	4.571	4.714	3.714	4.571	3.000	3.286	2.429

Source: developed by the authors.

2. Carrying out normalization of the decision matrix. It solves:

- determining the sum of the values of the scores for each criterion $\sum_{k=1}^n x_{kj}$,
- calculation of the values of the normalized decision matrix, where the element $r_{ij} = \frac{x_{ij}}{\sum_{k=1}^n x_{kj}}$.

Since within our study all criteria have the same units of measurement (evaluated on a 5-point scale), this stage can be skipped.

3. Construction of a weighted normalized decision matrix (Tables 18, 19) using the criteria weight values defined above.

Table 18

Weighted normalized decision matrix (in the pre-war situation)

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
EnC1	0.334	0.315	0.713	0.473	0.584	0.667	0.483
EnC2	0.316	0.355	0.811	0.453	0.605	0.647	0.501
EnC3	0.501	0.631	0.639	0.532	0.438	0.605	0.334
EnC4	0.390	0.572	0.442	0.473	0.501	0.480	0.446
EnC5	0.501	0.631	0.663	0.513	0.480	0.626	0.316

Source: developed by the authors.

Table 19

Weighted normalized decision matrix (under martial law)

Criterion	K1	K 2	K 3	K 4	K 5	K 6	K 7
Weight	0.130	0.138	0.172	0.138	0.146	0.146	0.130
Function	max	max	max	max	min	min	min
EnC1	0.520	0.591	0.565	0.453	0.647	0.542	0.297
EnC2	0.539	0.631	0.663	0.651	0.480	0.438	0.334
EnC3	0.483	0.611	0.663	0.591	0.501	0.480	0.334
EnC4	0.427	0.552	0.713	0.572	0.667	0.647	0.353
EnC5	0.594	0.651	0.639	0.631	0.438	0.480	0.316

Source: developed by the authors.

4. Ranking goals of sustainable development by environmental component.

4.1. Calculation of the weighted sum of the estimates of the i -th objective by criteria that have a monotonically increasing objective function. Calculation of the weighted sum of the estimates of the i -th objective by criteria that have a monotonically descending objective function:

$$S_{+i} = \sum_{j=1}^m w_{+j} * r_{+ij},$$

$$S_{-i} = \sum_{j=1}^m w_{-j} * r_{-ij}.$$

4.2. Calculating the value Z_{+i} , Z_{-i} та Z_i for each goal by formulas:

$$Z_i = S_{+i} + \frac{\sum_{k=1}^n S_{-k}}{S_{-i} * \sum_{k=1}^n \frac{1}{S_{-k}}} = Z_{+i} + Z_{-i},$$

$$Z_{+i} = S_{+i},$$

$$Z_{-i} = \frac{\sum_{k=1}^n S_{-k}}{S_{-i} * \sum_{k=1}^n \frac{1}{S_{-k}}}.$$

4.3. Determining the ranking of goals (Table 20) based on the Z_i values. The larger the value of Z_i , the more attractive the alternative is.

Table 20

Ranking of sustainable development goals by environmental component

In the pre-war situation							
	S_{+i}	S_{-i}	$1/S_{-i}$	Z_{+i}	Z_{-i}	$Z_i = Z_{+i} + Z_{-i}$	Rank
EnC1	1.835	1.734	0.577	1.835	1.357	3.192	5
EnC2	1.935	1.753	0.570	1.935	1.343	3.278	4
EnC3	2.303	1.377	0.726	2.303	1.709	4.012	1
EnC4	1.877	1.427	0.701	1.877	1.649	3.526	3
EnC5	2.308	1.422	0.703	2.308	1.655	3.963	2
Σ		7.713	3.277				
Under martial law							
	S_{+i}	S_{-i}	$1/S_{-i}$	Z_{+i}	Z_{-i}	$Z_i = Z_{+i} + Z_{-i}$	Rank
EnC1	2.129	1.486	0.673	2.129	1.285	3.588	1
EnC2	2.484	1.252	0.799	2.484	1.525	3.460	2
EnC3	2.348	1.315	0.760	2.348	1.452	3.329	5
EnC4	2.264	1.667	0.600	2.264	1.145	3.453	3
EnC5	2.515	1.234	0.810	2.515	1.547	3.382	4
Σ		6.954	3.642				

Source: developed by the authors.

As we can see from the environmental component, modern challenges have significantly affected the priority structure of implementing the Sustainable Development Goals in Ukraine. In the pre-war period, the priority goals

were "mitigating the effects of climate change" and "preserving terrestrial ecosystems". During the war period, the goals of "clean water and proper sanitation" and "affordable and clean energy" were the first.

Discussion and conclusions

The proposed algorithm for conducting a comprehensive assessment of the priority of sustainable development goals allowed us to substantiate a methodological approach to grouping them according to economic, environmental, and social indicators, with a generalization of the criteria for their selection. Ranking the sustainable development goals in the pre-war and martial law conditions allowed us to identify the changes that have occurred.

The modern challenges that Ukraine faces today have somewhat changed the priority of implementing sustainable development goals across all components of sustainable development:

- According to the economic component, "peace and justice" and "partnership for sustainable development" are becoming relevant for Ukraine. In the pre-war period, the highest priority was "sustainable development of cities and regions".

- In terms of the social component, the goals of "decent work and economic growth" and "quality education" are the first. They serve as a basis for further post-war reconstruction of Ukraine.

- In terms of the environmental component, the goals of "affordable and clean energy" and "clean water and adequate sanitation" became prioritized. They pushed into the background the pre-war goals of "mitigating the effects of climate change" and "preserving terrestrial ecosystems".

Thus, the war in Ukraine has brought to the fore the issue of theoretical discourse around the priority of sustainable development components for our state. But the war did not change the desire of entrepreneurs to solve their economic problems, taking into account the development of the concept of sustainable development, solving social issues, and respecting the environmental interests of society.

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ОЦІНЮВАННЯ ПРІОРИТЕТНОСТІ ЦІЛЕЙ СТАЛОГО РОЗВИТКУ В УМОВАХ СУЧАСНИХ ВИКЛИКІВ ДЛЯ УКРАЇНИ

Вступ. Світова пандемія коронавірусу, економічні, соціальні й екологічні виклики під час повномасштабного вторгнення вкрай негативно вплинули на систему взаємодії між бізнесом, споживачами, партнерами та стейкхолдерами. Сучасний діловий ландшафт потребує скоординованих дій світової спільноти для встановлення рівноваги в екосистемі вітчизняного бізнесу в процесі взаємодії з міжнародними донорами та потенційними інвесторами. Повномасштабне вторгнення є каталізатором стійкості вітчизняного бізнесу та можливості забезпечити економічне виживання з одночасним збереженням соціальної відповідальності й екологічних інтересів природних екосистем.

Методи. Одним із завдань дослідження є визначення пріоритетності реалізації цілей сталого розвитку в різні періоди (до війни та під час війни) та виявлення змін, що відбулися. Розв'язання завдання визначення пріоритетності реалізації зазначених цілей на практичному рівні можна звести до їхнього рейтингування в межах кожної складової із застосуванням методів багатокритерійного аналізу, які широко представлені у теорії та практиці управління. Для розв'язання поставлених завдань дослідження у статті використано методи оцінювання альтернатив TOPSIS, SAW, COPRAS.

Результати. Сучасні виклики, з якими Україна зіткнулася нині, децю змінили пріоритетність реалізації цілей сталого розвитку за всіма складовими. Наприклад, за економічною складовою актуалізуються для України "мир і справедливість" і "партнерство заради сталого розвитку". За соціальною складовою – на першому плані цілі "гідна праця та економічне зростання" та "якісна освіта", які по суті виступають базою для подальшого повоєнного відновлення України. За екологічною складовою найбільш пріоритетними стали цілі "доступна та чиста енергія" і "чиста вода й належні санітарні умови".

Висновки. Війна в Україні актуалізувала питання щодо теоретичного дискурсу навколо пріоритетності складових сталого розвитку для нашої держави, але не змінила прагнення підприємців розв'язувати свої економічні проблеми з урахуванням розвитку концепції сталого розвитку, вирішення соціальних проблем і дотримання екологічних інтересів суспільства.

Ключові слова: цілі сталого розвитку, методи багатокритерійного аналізу, економічна компонента сталого розвитку, соціальна компонента сталого розвитку, екологічна компонента сталого розвитку, пріоритетність цілей сталого розвитку.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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DATA-DRIVEN ATTRIBUTION MODELING IN DIGITAL MARKETING

Background. In the contemporary digital environment, marketing communications have evolved into multi-channel, personalized, and dynamic interactions, necessitating an increasingly precise quantification of the efficacy of each user touchpoint with a brand. Conventional rule-based marketing attribution models, which exclusively assign value to a singular touch-point of contact, no longer yield the requisite level of analytical granularity. In response to these methodological challenges, advanced economic and mathematical methodologies, notably models predicated on Markov chains and Shapley values, are progressively being deployed to facilitate a rigorously reasoned and quantitatively justifiable allocation of value across all contributing channels.

Methods. The research methodology is based on a combination of general scientific and specialized methods. Specifically, it utilized theoretical modeling, comparative analysis, as well as stochastic modeling (Markov chains) and cooperative game theory (Shapley values).

Results. This research rigorously investigated marketing attribution in the digital environment, demonstrating the inherent limitations of traditional rule-based models and substantiating the superior efficacy of adaptive approaches, particularly Markov chains and Shapley values. The empirical implementation and comparative analysis of the Shapley value model confirmed its enhanced precision and capacity to objectively quantify each channel's contribution, leading to actionable insights for strategic marketing optimization. This study provides a robust framework for understanding multi-touch attribution, emphasizing the critical role of data-driven methodologies in contemporary marketing analytics.

Conclusions. The work is relevant for marketing analysts and digital strategy teams, as it presents a comparative analysis of rule-based and algorithmic attribution models and offers practical solutions for campaign optimization. The Shapley Value model was implemented in Python and tested on real-world marketing data. The practical value lies in the ability to use the results for better budget allocation, identifying undervalued channels, and increasing return on marketing investment (ROMI).

Keywords: marketing attribution, digital marketing, data-driven attribution, Shapley values, Markov chains, multichannel analytics, Python.

Background

In the contemporary digital landscape, marketing communications have evolved to become multichannel, personalized, and dynamic, thereby intensifying the need for precise measurement of the effectiveness of each user interaction with a brand. In this context, marketing attribution emerges as a response to the growing demand for understanding the actual contribution of each channel to business outcomes. The primary objective of marketing attribution is to assist brands in discerning the significance of every touchpoint within the broader customer journey. By identifying which channels or touchpoints yield higher conversion rates, marketing teams can optimize budget allocation and communication strategies. Such insights enable marketers to clearly recognize the sequences of user actions that most frequently lead to desired behaviors and, ultimately, to conversions. Moreover, marketing attribution enhances the customer experience by facilitating a deeper understanding of the customer journey, highlighting pivotal touchpoints, and identifying areas for improvement.

As a technical process, marketing attribution entails the systematic collection, processing, and analysis of user interaction data. The data collection stage is implemented through core tracking technologies such as cookies, tracking pixels, UTM tags, and other mechanisms that enable the identification of traffic sources and user behavior on websites. These data, in turn, form the foundational basis for constructing effective attribution models.

Traditional rule-based marketing attribution models, which attribute the entirety of value to a singular touchpoint, no longer provide a sufficient level of analytical precision. In response to these limitations, attention is increasingly gravitating towards the adoption of data-driven attribution models. While the market currently furnishes a diverse array of tools enabling the application of classification algorithms, Bayesian analysis, and other techniques for marketing attribution, substantial potential remains for advancing this class of models through more sophisticated mathematical approaches. Specifically, stochastic modeling and game theory present compelling avenues for development. In

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particular, Markov chain models and Shapley value-based approaches enable a rational and quantitatively verifiable allocation of value across all digital marketing channels. The adoption of such models thus presents novel opportunities for developing evidence-based frameworks for marketing resource allocation and for the strategic governance of communication channels. Consequently, research into marketing attribution models retains substantial relevance. This imperative is driven, on the one hand, by the exigencies arising from the escalating complexity of the modern digital landscape, alongside heightened demands for computational precision, analytical transparency, and judicious budget management; and, on the other hand, by the imperative for businesses to access practical tools for resolving marketing attribution challenges.

The paper aims to propose an accessible, high-quality, and effective data-driven tool for addressing marketing attribution challenges within today's complex digital multichannel environment. To achieve this objective, several key tasks were undertaken: conducting a comparative analysis of current marketing attribution models in terms of their capabilities and limitations in practical digital marketing applications; outlining the strong potential of data-driven approaches – particularly stochastic and game-theoretic models – for enhancing the accuracy of channel contribution evaluation in a complex multichannel context; conceptualizing the process of attribution modeling based on Shapley values using Python libraries; and practically implementing the proposed approach using real-world marketing campaign data to develop actionable recommendations for improving digital marketing performance.

The research findings demonstrate that rational and effective marketing attribution models, along with accessible tools, can be successfully adopted by companies of various sizes and levels of IT infrastructure maturity. These tools can contribute to improved marketing campaign performance, more efficient advertising budget allocation, and better decision-making based on more accurate analytical models.

Literature review. Recent years have witnessed substantial advancements in the field of digital marketing, particularly in attribution modeling, which enables companies to more effectively assess the impact of their marketing efforts. Foundational studies, such as the systematic review (Dhar, & Singh, 2020), underscore the escalating complexity and paramount importance of attribution modeling for comprehending customer pathways to conversion, concurrently providing a comprehensive overview of extant methodologies and delineating prospective research trajectories. Similarly, a review (Yusup et al., 2024) centers on the pivotal role of artificial intelligence within digital marketing, a factor critical to the advancement of novel algorithmic attribution models.

Modern attribution approaches actively employ advanced algorithmic techniques. The authors of such a study (Lee et al., 2021) conduct a comparative analysis and interpretation of models for predicting online conversions, an integral component of assessing marketing touchpoint efficacy. Karray, Martín-Herrán, and Sigué (2022) address the management of advertising investments across marketing channels, thereby underscoring the critical importance of multichannel analytics and strategic budget allocation. Particular emphasis is placed on models capable of accounting for the intricate interactions among touchpoints. Dhar and Singh (2020) presented a comprehensive literature review on attribution modeling in marketing, offering a solid theoretical foundation and identifying key directions for future research. Furthermore,

other researchers (Zhao, Mahboobi, & Bagheri, 2022) delve into game-theoretic models of marketing attribution, enabling the equitable distribution of value among various marketing channels based on their incremental contribution, notably through the application of Shapley value theory.

Understanding user behavior and optimizing advertising activities are central to effective digital marketing. A simulation-based model is proposed to forecast the dynamics of consumer behavior under digital advertising influence and to support budget allocation decisions (Dorokhova et al., 2023). Furthermore, contemporary research actively utilizes data science for modeling. Some studies (Chornous, & Farenjuk, 2021) apply data science technologies to model the marketing mix in pharmaceutical companies, demonstrating the practical application of algorithmic models for evaluating investment effectiveness. Ben Mrad and Hnich introduce an intelligent attribution modeling framework in this context (Ben Mrad, & Hnich, 2024) that leverages advanced analytics to optimize digital marketing performance. Likewise, Seth and Ramakrishnan present innovations in multi-touch attribution models tailored to the pharmaceutical sector, moving beyond traditional marketing analytics to capture the nuanced contributions of diverse channels (Seth, & Ramakrishnan, 2025).

Recent literature demonstrates a significant evolution of marketing mix modeling (MMM) and attribution analytics, moving from classical brand-management frameworks (Cain, 2014) toward data-driven, digitally oriented methodologies. Studies on digital strategy adaptation (Dumitrescu et al., 2018) and foundational reviews of attribution modeling (Gaur, & Bharti, 2020; Mathew, 2016) highlight the increasing analytical complexity of evaluating channel effectiveness. Research further explores advanced approaches for multi-channel attribution across competitors (Li et al., 2017) and the shift toward inferential and post-cookie attribution techniques (Kamena, 2021; Hosahally et al., 2025). Modern MMM has progressed from traditional regression models to AI-powered and neural-network-based architectures (Gujar et al., 2024; Mulc et al., 2025), while applications in real business environments confirm their practical suitability (Ravid, 2025; Sciarrino et al., 2025). Additional studies emphasize model comparison (Sharma, Meena, & Ibrahim, 2017), omnichannel attribution challenges (Méndez-Suárez, & Monfort, 2021), and the integration of multi-information fusion to bridge MTA and MMM (Zhou, Pei, & Li, 2024). Together, these works reflect a consolidated trend toward more granular, algorithmic, and privacy-resilient attribution models in contemporary digital marketing.

A review of contemporary literature reveals a growing trend towards applying sophisticated algorithmic models based on game theory, machine learning, and stochastic modeling (including Markov chains) for more precise marketing attribution and investment optimization in digital and multichannel marketing. These studies form the foundation for more effective strategies that consider the dynamics of consumer behavior and the complexity of interactions between marketing channels. This paper conducts a comparative analysis of modern attribution models and proposes and implements a model based on Shapley values in a Python environment, which can be beneficial for real-world businesses of various sizes and IT infrastructure maturities.

Methods

The paper employs both general scientific and specialized research methods. General scientific methods include the dialectical method, systems approach, methods of analysis and synthesis, and induction and deduction.

Within the framework of economic-mathematical modeling, stochastic modeling (Markov chains) and elements of cooperative game theory (specifically, Shapley values) are considered. The methodological toolkit of the study also encompasses methods from probability theory, rule-based modeling, data analysis and processing using the Python programming environment (pandas, numpy, matplotlib libraries), methods of comparative analysis, and results visualization. The application of these approaches ensured a comprehensive analysis of the selected problematic area and enhanced the reliability of the conclusions drawn.

The marketing attribution models examined in the study are categorized into two main groups: deterministic (rule-based models) and adaptive (algorithmic). The first group of models includes Single-Touch Attribution Models, specifically First Touch Attribution and Last Click Attribution, as well as Multi-Touch Attribution Models such as Linear Attribution, Time-Decay Attribution, Position-Based Attribution, W-Shaped Attribution, and Custom Attribution (Sun, 2023). Web analytics platforms, such as Google Analytics, traditionally use a Single-Touch Attribution approach by default for conducting attribution analysis.

Adaptive models study historical user data to identify patterns in interactions with marketing channels. Among these models, the most common is the data-driven attribution approach (Ben Mrad, & Hnich, 2024), which involves using classification algorithms, Bayesian analysis, or ensemble methods to distribute value among channels based on their actual contribution to conversion. The group of adaptive models also includes Markov chains, which are probabilistic models explored in this study. Markov chains enable the representation of user interaction sequences and the calculation of transition probabilities between touchpoints (Mehta, & Singhal, 2020). Markov chains are characterized by a defined state space, a transition matrix (describing probabilities between states), and an initial state or distribution. The constructed graph represents interaction points with existing transitions corresponding to specific probabilities. Graph construction is based on historical user interaction data. Conversion is modeled as a final state, while abandonment (null) is an alternative terminal state. To assess the significance of each channel, the "removal effect" approach is applied. This involves analyzing how the elimination of a specific node impacts the probability of achieving conversion (e.g., purchase, other primary action). Markov chains effectively account for not only the sequence of touchpoints but also their interdependencies, including the presence of cycles (loops) that occur when a user

repeatedly interacts with the same channel. For more complex graphs with numerous cycles, iterative approximation methods are used to estimate conversion probability, even with an infinite number of possible paths.

The Shapley value model implemented in this study originates from game theory. The main problem addressed by the Shapley value is the fair distribution of credit in a game where players can form coalitions (Zhao, Mahboobi, & Bagheri, 2022). In the context of marketing attribution, game theory is utilized to model customer interactions with marketing channels as a cooperative game, where each marketing channel can be viewed as a player. The collective of all players/channels works together to drive conversions and assigns each touchpoint fair credit (using these Shapley values) for a conversion based on its true contribution. The calculation of Shapley values for each channel i is performed using the formula:

$$\phi_i(N, v) = \frac{1}{|N|!} \sum_{S \subseteq N \setminus \{i\}} |S|! (|N| - |S| - 1)! \cdot [v(S \cup \{i\}) - v(S)], \quad (1)$$

where N – the set of all channels (players); $S \subseteq N \setminus \{i\}$ – a subset of channels not including channel i ; $v(S)$ – the value function (conversion rate) generated by the coalition S ; $v(S \cup \{i\}) - v(S)$ – marginal contribution of channel i to coalition S ; $|S|! (|N| - |S| - 1)!$ – weighting factors considering the number of permutations of channels before and after the inclusion of channel i .

For each channel, all coalitions to which it does not yet belong are iterated over, and its marginal contribution to each of them is evaluated. The marginal contribution is defined as the difference between the value of the coalition after the inclusion of the given channel and its initial value:

$$\text{contrib}_i(S) = v(S \cup \{i\}) - v(S). \quad (2)$$

The contribution can be weighted using a combinatorial coefficient that accounts for the number of possible orders in which the channel can enter the coalition:

$$\text{weight}_i(S) = \frac{|S|! (|N| - |S| - 1)!}{|N|!}. \quad (3)$$

Thus, the Shapley model provides an objective and mathematically justified assessment of each channel's contribution to conversion based on its marginal effect across all possible channel coalitions.

Results

Model Comparison. The analysis of rule-based attribution models has revealed their advantages but also highlighted significant limitations, primarily in their ability to accurately capture the complex nature of consumer behavior. Table 1 presents a comparative overview of the main traditional marketing attribution models.

Table 1

Comparative Table of Main Rule-Based Marketing Attribution Models

Attribution model	Value Distribution	Optimal Use Case
First Touch	All value is assigned to the first touchpoint	Measuring the effectiveness of initial brand awareness
Last Touch	All value is assigned to the last touchpoint	Determining the final influence on decision-making
Linear	Value is evenly distributed across all touchpoints	When all touchpoints are considered equally important in the conversion process
Time-decay	More value is given to recent interactions, less to earlier ones	For longer sales cycles or when recent interactions have a stronger impact on conversion
Position-based	Value is distributed among different touchpoints (depending on the model or platform)	When both the first and last interactions are important
Custom	Value is assigned according to what is most important for the business	Best suited for companies with specific goals or unique customer journeys

Source: compiled by the authors.

Against the backdrop of the limitations of traditional models, adaptive approaches are gaining increasing importance. These approaches account for temporal dynamics, the sequence of touchpoints, and their statistical significance in driving conversion.

Markov chains effectively model the interrelationships between marketing channels, considering the sequence of actions, repeated interactions (cycles), and context in higher-order models. They are particularly useful for analyzing complex and long conversion paths where

traditional attribution models are insufficient. The application of the "removal effect" metric allows for the identification of channels with a critical impact on conversion, while robustness to noise and flexibility ensure the model's scalability. Nevertheless, the model has several limitations: it is based on correlations rather than causal relationships, which may lead to erroneous attribution of results to channels. Additionally, the classical "memoryless" approach does not always accurately reflect user behavior in complex scenarios. Model implementation requires a significant volume of data, access to complete user paths (including non-converting ones), and the use of specialized computational tools. Despite these challenges, Markov chains remain a powerful tool for evaluating channel effectiveness, provided a critical approach is taken to modeling and interpreting results.

The Shapley value model is widely used in the analytical systems of major advertising platforms to quantitatively assess the contribution of marketing channels to conversions by analyzing all possible channel coalitions.

Due to the exponential growth in the number of combinations, its practical implementation requires substantial computational resources. To enable scalability for large datasets, approximation techniques and SHAP (SHapley Additive exPlanations) tools are commonly employed. The key advantages of the model include a fair and proportional allocation of channel influence that accounts for channel interactions, enhancing both interpretability and predictive accuracy compared to traditional approaches. At the same time, the model is constrained by high computational complexity, sensitivity to data variation, the need for large volumes of detailed data, and the inability to account for the sequence of interactions. These limitations highlight the need for further development of extended versions and efficient algorithmic solutions.

Table 2 presents a comparative analysis of the main characteristics of Markov chain-based and Shapley value-based attribution models.

Table 2

Comparative Analysis of Markov Chain-Based and Shapley Value-Based Attribution Models

Comparison feature	Markov chain-Based Model	Shapley value-Based Model
Model Type	Probabilistic, sequential	Game-theoretic, cooperative
Analysis of Channel Order Context	Takes the transition order into account	Order is not critical
Dependence on Temporal Structure	High	Minimal
Consideration of Channel Interactions	Limited, based on transitions	Comprehensive, considers all coalitions
Robustness to Sample Size Variation	High with large samples	Depends on computational resources
Computational Complexity	Moderate	High (exponential growth)
Flexibility to Adapt to Complex Scenarios	Limited by the first-order model	High due to the coalition-based approach
Interpretability of Results	High, but requires an explanation of the transition probability matrix	High, especially with SHAP visualizations
Dependence on Specification of Payoff Function (Business Goals)	Does not require an explicit definition	Requires a characteristic function
Relevance in Modern Tools	Common in web analytics	Integrated in modern ML platforms

Source: compiled by the authors.

The comparative analysis indicates that the Markov chain model is effective for accounting for the order of actions and is less resource-intensive, whereas the Shapley value model provides a more precise evaluation of each channel's contribution but requires substantial computational resources. Therefore, the choice between the two depends on the complexity of user paths, analytical objectives, and available resources. Both models have practical applications; however, in scenarios involving complex funnels and a high demand for attribution accuracy, the Shapley value model should be preferred. The following conceptual steps are proposed for its implementation in Python.

Conceptualization. The first stage involves performing preliminary data analysis. Using the Python libraries pandas, numpy, and matplotlib, the dataset is loaded and its structure is initially explored (including general data overview and exploratory data analysis – EDA), missing values and anomalies are identified, key variables are determined, and preliminary visualizations of interactions between variables are created (libraries matplotlib, seaborn, and plotly.express).

Next, data preparation for modeling is conducted. This stage includes aggregating data to the user level by constructing ordered sequences of channels (user journeys), which enables the representation of individual interaction paths with the campaign. For each user, a set of channels interacted with is formed, along with a record of whether a conversion occurred. A coalition table is created containing unique channel combinations and the

corresponding number of conversions, providing a basis for subsequent calculations.

The following step is building the attribution model based on Shapley values. The methodology involves generating the full set of possible channel coalitions, calculating the marginal contribution of each channel across all possible combinations, and normalizing the results to obtain relative influence shares. The resulting values are visualized using Python's graphical tools to enhance interpretability and facilitate comparison of individual channel contributions.

To improve the robustness of the analysis, it is advisable to additionally implement rule-based marketing attribution models, such as Linear Attribution and Last Touch Attribution. This allows for the comparison of the adaptive approach results with traditional methods, identification of key discrepancies in channel contribution assessments, and evaluation of model quality through benchmarking against baseline methods. To implement the previous three steps, in addition to the aforementioned Python libraries (such as NumPy and pandas), the study also employed Seaborn and Plotly Express libraries for data visualization, as well as the built-in Python modules itertools.combinations for working with iterators and collections.defaultdict for enhanced data structures.

The next stage involves a comparative analysis of the obtained results, during which the effectiveness of channels across different attribution models is evaluated. This analysis enables the identification of key channels that demonstrate consistent influence across various approaches, as well as the detection of channels whose

contribution significantly increases only within the context of multichannel interactions.

The final stage consists of formulating conclusions and practical recommendations for optimizing marketing budgets, enhancing channel effectiveness, and designing multichannel campaigns based on attribution results. These insights empower companies to make informed and rational strategic decisions grounded in data.

Experiment. To develop the Shapley value-based attribution model, a real dataset from a digital advertising campaign was utilized, comprising 10,037 records of user interactions with various marketing channels throughout January 2018. The campaign promoted a digital product offering online educational services. The key variables selected for modeling include *user_id* (a unique identifier distinguishing individual users within the dataset), *marketing_channel* (indicating the channel through which the marketing message was delivered: Email, Facebook, Instagram, Push, House Ads), *date_served* (the date the marketing message was shown, necessary for determining the order of touchpoints in the user journey), and *converted* (a binary variable: True if the user completed a conversion such as a purchase or subscription following the interaction, False otherwise. This is the primary target variable for attribution modeling as it defines interaction success. These variables contain a minimal amount of missing data (up to 0.2%) and allow tracking of individual user paths to

conversion. Other subscription-related variables were excluded due to their irrelevance to the attribution analysis. Missing values in critical variables were handled by row deletion without compromising data quality. Exploratory data analysis focused on deriving insights, verifying data distributions, and preparing for modeling, with particular attention to the conversion rate, frequency of channel usage, and channel combinations leading to conversions. The analysis revealed a moderate class imbalance, with successful conversions (*converted* = True) constituting approximately 60% of observations and unsuccessful ones (*converted* = False) about 40%, which is favorable for model training without additional adjustment. Regarding channel usage, House Ads emerged as the most engaged channel with over 250 impressions, followed by Instagram and Facebook (~105 impressions each), indicating an uneven distribution of marketing efforts. The relationship between impression frequency and number of conversions showed a direct linear correlation: House Ads led both in impressions and conversions, whereas Instagram and Facebook exhibited high conversion rates despite fewer impressions. Email and Push had limited impressions and correspondingly fewer successful interactions. These findings confirm that an increase in interaction volume directly correlates with a rise in the absolute number of conversions (Fig. 1).

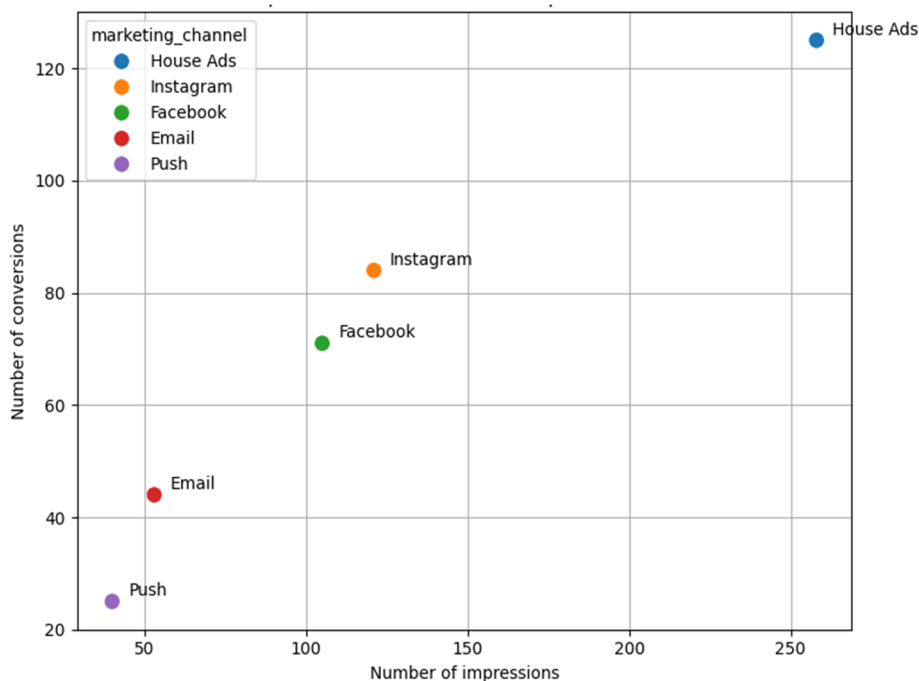


Fig. 1. Relationship Between the Number of Impressions and Conversions

Source: Compiled by the authors using Python environment

Continuing the analysis of channel effectiveness, the next stage focused on examining the interrelationships among marketing channels that appear together within a single user's journey. Frequency of impressions and conversion rates – even when combined with conversion share metrics – do not fully capture the multichannel nature of digital campaigns. It is therefore essential to identify which channels most frequently co-occur in user interactions. A channel co-occurrence matrix constructed in the Python

environment (see Fig. 2) revealed that House Ads is the most integrated channel, frequently appearing alongside Instagram (70 cases), Facebook (43), and Push (20), emphasizing its central role in the campaign. Instagram also frequently co-occurs with Facebook (29), forming a stable interaction cluster. In contrast, Email and Push are less commonly found in combinations, typically appearing in isolated or supplementary scenarios.

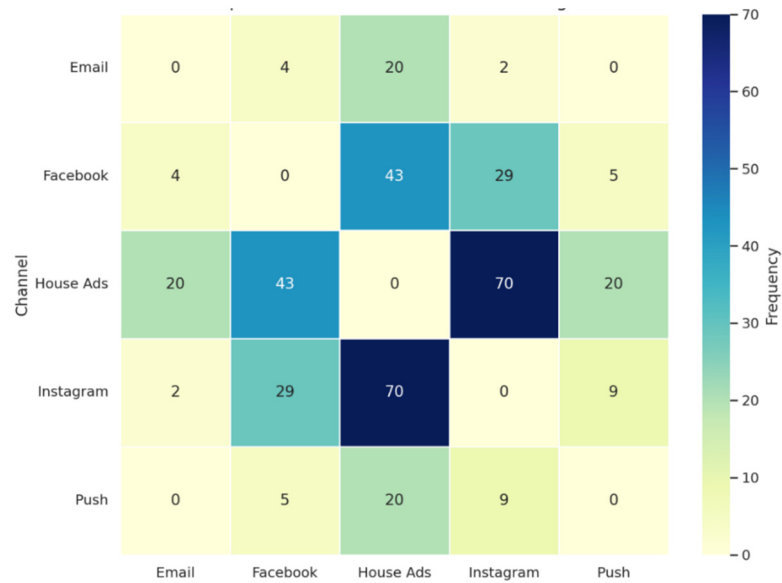


Fig. 2. Heatmap of Channel Co-Occurrence Frequency per User

Source: Compiled by the authors using Python environment

The data indicate a moderate class imbalance, with approximately 60% of interactions resulting in conversions. House Ads clearly dominate in both the number of impressions and conversions, followed by Instagram and Facebook in intermediate positions. Although Email demonstrated a lower reach, it exhibited a high conversion rate when applied in a targeted manner. The analysis of channel combinations confirms the central role of House Ads and the strong interconnection between Instagram and Facebook, which constitutes an important business insight for evaluating the results of attribution models.

In the next stage of the study, a Shapley value-based marketing attribution model was constructed to determine the marginal contribution of each marketing channel to conversions, taking into account all possible combinations of its occurrence in user paths. Before calculating the Shapley values, the data were aggregated at the user level:

for each user_id, the unique marketing_channel values that appeared in the sequence of impressions were concatenated. The uniqueness function ensured that each channel in a user journey was considered only once, but preserved the order of appearance. The result was a string such as 'Email, Push, Facebook', representing the user's journey. Each user was also assigned a binary label indicating whether their path ended in a conversion.

The following step involved grouping users by unique channel combinations, reflecting all observed channel coalitions in actual journeys. For each such coalition, the number of conversions completed by users who followed that specific path was calculated. As a result, an aggregated coalition combination was constructed, with each entry representing a specific channel combination along with the corresponding number of successful conversions (Fig. 3).

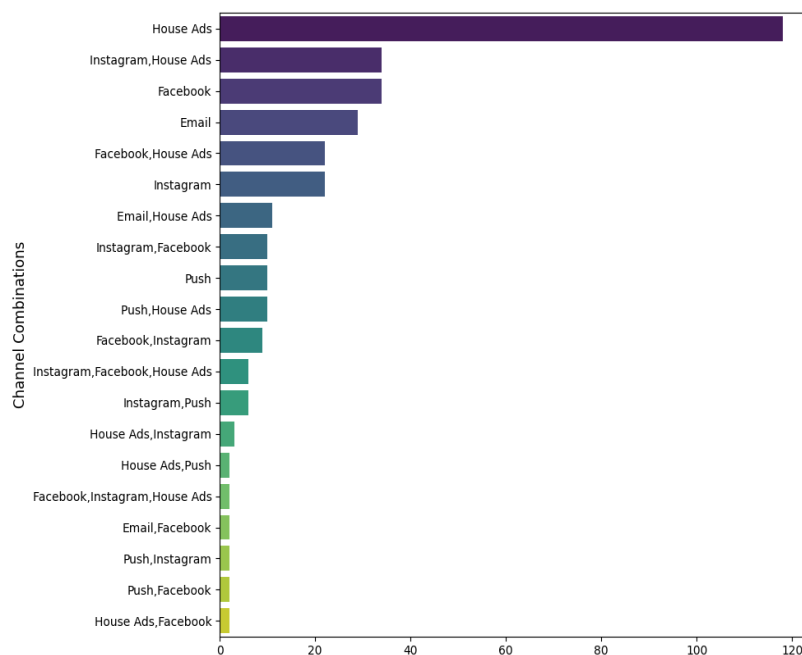


Fig. 3. Main Channel Combinations by Conversions

Source: Compiled by the authors using Python environment

To proceed with the calculation of Shapley values, a complete set of potential channel coalitions that could theoretically arise within user interactions was generated. This involved creating all possible non-empty subsets from the available list of channels, including individual channels, pairs, triplets, and so forth. These subsets are treated as coalitions, with each possessing a potential "value", i.e., the number of conversions associated with that specific channel combination (Cooper, 2022). For this stage, a function was implemented that, given a list of channels, generates all possible combinations (subsets) of length from 1 to n , where n is the number of unique channels in the dataset. These combinations represent all configurations in which the channels may jointly appear. An auxiliary function converts each subset into a sorted string format (e.g., 'Email, Facebook'), ensuring consistent storage of values in subsequent dictionaries. This process produced the analytical space of all possible coalitions, forming the foundation for computing the marginal contribution of each channel.

The next stage involved defining the value function $v(S)$, which calculates the overall "value" or effectiveness of a given coalition – its conversion strength. For each coalition (e.g., ['Email', 'Facebook']), the function searches for all its subsets (such as ['Email'], ['Facebook'], and ['Email, Facebook']) and sums their corresponding values from the conversion_dict.

$$v(S) = \sum_{T \subseteq S} \text{conversion}(T), \quad (4)$$

where S denotes a coalition of channels, and T refers to a subset of S that is present in the conversion dictionary.

For example: $v(['Email', 'Push']) = \text{conversion}('Email') + \text{conversion}('Push') + \text{conversion}('Email, Push')$.

Next, the Shapley values for each channel i were calculated using the classical formula (1).

The calculation was implemented as a separate function that received as input an aggregated Data Frame containing channel combinations and the corresponding number of conversions for each. From this Data Frame, a dictionary was created where the keys were strings representing the channel combinations (e.g., "Email, Push"), and the values represented the number of conversions attributed to each coalition. This structure enabled efficient access to the necessary values during computation. Subsequently, all channels that appeared in solo combinations – i.e., in user paths where only one channel was encountered – were identified. The next step involved calculating the coalition value function, as previously defined, for all possible subsets of channels. For example, if a coalition consisted of three channels, its value was computed

as the sum of conversions for all single, pairwise, and triple combinations present in the dataset. For each channel, all coalitions in which it was not initially present were iterated over, and its marginal contribution to each was evaluated (using formulas (2) – (3)).

As a result, each channel received a Shapley value, interpreted as its average marginal contribution to achieving a conversion, taking into account all possible coalitions and interaction sequences. The highest Shapley value was observed for the House Ads channel, with a contribution of 137.33, indicating its critical role in the user's path to the target action. This result confirms not only its high frequency of use but also its significance in combinations with other channels – House Ads consistently delivers the highest incremental value to the coalitions it is part of. Facebook ranked second in terms of influence, with a Shapley value of 51.83, reflecting the channel's stable effect both in solo and multi-channel pathways. Email and Instagram demonstrated similar levels of influence – 36.33 and 31.50, respectively – indicating moderate yet systematic involvement in conversion chains. The lowest contribution was observed for Push (15.00), which correlates with its less frequent usage and limited marginal effect in the context of interactions with other channels.

To evaluate the results, normalization of the values was performed by converting the absolute contributions of the channels into relative shares (Table 3). This process involved dividing each channel's contribution by the total sum of contributions, thus determining its share of the overall conversion impact. House Ads accounts for 50% of the total influence. While functionally effective, this also indicates a potential dependence of the overall conversion strategy on this internal channel. Such a concentration poses a risk of overreliance but simultaneously presents an opportunity to scale this successful pattern to external or emerging channels. Facebook, with a share of 19.06%, may serve as a connecting touchpoint between user interactions across different channels. This signals the potential for further investment in Facebook as a channel with growth capacity through enhanced engagement. Email and Instagram exhibit relatively similar performance – 13.36% and 11.58%, respectively – demonstrating consistent, though moderate, contributions to conversion. Push notifications represent only 5.51% of the total. Despite the low share, this communication channel holds potential for targeted impact, particularly in reactivating dormant users or executing time-sensitive promotional campaigns.

Table 3

Normalized percentage contributions of channels to conversion according to three attribution models, %

Marketing Channel	Attribution Model		
	Shapley Values Attribution	Linear Attribution	Last Touch Attribution
House Ads	50.49	47.86	60.23
Facebook	19.06	18.08	14.62
Email	13.36	10.62	8.48
Instagram	11.58	16.81	10.82
Push	5.51	6.63	5.85

Source: compiled by the authors.

To evaluate the effectiveness of the developed model and validate the accuracy of the calculated contributions, its results were compared with classical rule-based attribution models, which constituted the next step of the study. Specifically, the logic of the Linear Attribution model was implemented, in which the contribution to conversion is evenly distributed among all channels present in the user's journey. This model does not account for the order of

influence but only for the presence of a channel. Each channel involved in the path to conversion receives an equal share of the attribution. After normalizing the contribution of each channel, the highest percentage contribution, similar to the Shapley Values model, was assigned to the House Ads channel (47.86%). Facebook ranked second (18.08%), followed by Instagram (16.81%), while Email accounted for 10.62%. The smallest share was assigned to Push

notifications (6.63%). Additionally, a Touchpoints table (Table 4) was created to determine the specific stage in the user journey at which each channel had the greatest impact. For instance, in the sequence Email → Facebook → House

Ads, Email corresponds to Touchpoint 1, Facebook to Touchpoint 2, and House Ads to Touchpoint 3. The maximum number of touchpoints in the dataset is three.

Table 4

Distribution of Channel Contribution by Touchpoints (Linear Attribution)

Channel	Touchpoint 1 (%)	Touchpoint 2 (%)	Touchpoint 3 (%)	Total (%)
House Ads	44.07	61.44	100.0	47.86
Facebook	18.68	16.49	0.0	18.08
Instagram	17.90	13.03	0.0	16.81
Email	13.18	0.00	0.0	10.62
Push	6.17	09.04	0.0	6.63

Source: compiled by the authors.

The analytical results indicate that the House Ads channel demonstrates dominance across all stages of the user journey, including the final touchpoint. Facebook and Instagram primarily appear at the initial and intermediate stages (1st–2nd touchpoints), thus serving as acquisition or supporting channels. Consequently, their contribution to the final conversion may be underestimated by traditional attribution models, such as the Last Touch approach. Email frequently functions as the initial point of contact that initiates user engagement (e.g., via newsletters) and, in certain instances, may independently lead to conversion within a single-step purchase path. Push notifications act as supplementary communication tools, predominantly occurring within the first two touchpoints. They typically function as reminders activated through mobile applications and have a relatively limited impact on conversion outcomes.

The Last Touch Attribution model evaluates the impact of channels based on their role in concluding the user journey before conversion, disregarding previous interactions. It is suitable for scenarios where the final contact is considered decisive. According to the analysis conducted in Python, the leading channel is House Ads, accounting for 60.23% of conversions as the last touchpoint due to its dominance at the second and third touchpoints. This channel frequently serves as the final element in the communication chain, effectively "closing" the deal. Facebook (14.62%), Instagram (10.82%), and Email (8.48%) play less significant roles. Notably, Email appears exclusively at the first touchpoint and is absent from the second, meaning that under the Last Touch model, conversions associated with Email are attributed only when it serves as the initiating contact.

Within the framework of a comparative analysis of three attribution models – Shapley Values, Linear Attribution, and Last Touch Attribution – certain differences in the distribution of marketing channel contributions were identified. These findings allow for a series of conclusions regarding user behavior, the effectiveness of marketing efforts, and the characteristics of each model. The results of the channel contribution comparison are presented in Table 3.

First, the Last Touch Attribution model places maximum emphasis on the final point of contact, assigning the entire value of the conversion to the last channel in the user's journey. This leads to an overestimation of channels that frequently conclude interactions, particularly House Ads, which receive the highest share (60.23%). However, this model neglects prior stages of the user journey. Second, the Linear Attribution model distributes value evenly across all channels in the conversion path, reducing the weight of the final touchpoint and increasing the contribution of channels that consistently appear in multi-touch sequences, such as Instagram and Email. These channels demonstrate higher

contributions compared to the Last Touch model, as their supporting role in a multichannel context is recognized. Third, the Shapley Values model offers the most structured and mathematically grounded assessment by allocating the value of each channel according to its marginal contribution across all possible channel coalitions. This approach identifies channels whose effectiveness increases through interaction with others (e.g., Email, with a share of 13.36% under Shapley versus 8.48% under Last Touch), eliminates the "last-touch bias," provides a more realistic estimate of the weight of House Ads (50.49%), and consistently excludes low-impact channels such as Push, which maintains a minimal contribution across all models.

Thus, the differences in evaluation are determined by the conceptual assumptions of each model regarding the causal relationships between channels and conversion: Last Touch simplifies them to the final interaction; Linear distributes value evenly without considering context; Shapley assesses the actual impact, accounting for the sequence and interaction of channels. This is why Shapley Values is considered more appropriate for optimizing marketing budgets in complex multichannel environments.

Based on the implemented model, marketers gain valuable insights into the effectiveness of their marketing efforts and budget planning. Regarding the strongest conversion driver – House Ads (50.49%) – the following recommendations are appropriate: continue investing in internal advertising (in-app ads, banners, recommendation blocks within the interface); further unlock the channel's potential through enhanced personalization (e.g., adapting creatives based on past user interactions); use House Ads as a retargeting tool for users who have previously interacted with other channels (e.g., Email or Instagram); develop behavior-based scenarios (e.g., "House Ads only after email open").

Facebook (19.06%) – an effective support and engagement channel. It plays a role in both the upper and middle stages of the funnel, generating initial interest and maintaining the momentum of user transitions. Its contribution in coalitions is significant, especially in combination with House Ads. Recommendations for channel optimization: launch ad campaigns with detailed audience targeting (Lookalike Audiences based on conversion behavior); use Facebook as a "reminder" channel, especially in interaction sequences where it is not the first touchpoint; test video formats and interactive posts to increase engagement depth before the appearance of House Ads.

Email (13.36%) – a stable channel, yet requires systematic expansion of interactions. It does not function independently as a final trigger, but significantly amplifies the effect of combinations. The contribution in the Shapley model is higher than in Last Touch. Further integration of

email marketing at the final stages of the user journey is needed. As a core CRM tool, Email should re-engage users who did not convert at earlier stages. Recommended actions: identify audience segments with a high likelihood of email response (e.g., based on Retention data); apply trigger-based campaigns such as abandoned cart, re-engagement, and onboarding; conduct A/B tests on subject lines, send times, and CTA formats (call-to-action).

Instagram (11.58%) received higher scores in traditional models but lower scores in the Shapley model. The nature of this channel points to high visibility but a relatively weak marginal effect, indicating a limited impact on final decision-making and its appearance alongside more influential channels. It primarily builds emotional connection and enhances user engagement. Practical recommendations: use Instagram mainly at the early stages of the funnel (awareness), with creatives that build brand perception; integrate it with House Ads or Facebook to support multichannel communication; run campaigns linking to a landing page (LP) rather than just the brand profile to increase the likelihood of final conversion.

Push notifications (5.51%) – a low-impact channel in need of relaunch. It shows the smallest contribution across all models. Its influence is insufficient and poorly structured. As the channel with the fewest impressions, it requires traffic growth for proper testing and assessment of its effectiveness. There's a rationale to revise the tactic or audience targeting. Recommendations for optimization: shift to more personalized push notifications (e.g., referencing prior user actions); limit frequency and apply A/B testing – whether to send push before or after email or other channels; measure open time and its influence on re-engagement.

Therefore, by leveraging the flexibility and precision of the Shapley model, a company can effectively assess the marginal effect of each touchpoint. This approach will mitigate dependence on traditional models, which consistently overvalue the final stages of user interaction with channels. Concurrently, it will facilitate a more efficient allocation of the marketing budget, as channels with negligible impact will no longer receive disproportionate funding. Basing decisions on the actual impact of channels, rather than merely their frequency or reach, will enable more precise planning of multichannel campaigns. Ultimately, this will empower the company to formulate a truly coherent marketing strategy, wherein each channel functions as part of a synchronized system geared towards effective user engagement.

Discussion and conclusions

The study addresses the problem of marketing attribution in the modern digital environment and proposes effective approaches for modeling channel impact using both traditional and adaptive methods. The theoretical foundations of marketing attribution are summarized, and a comparative analysis of its principal models is presented. It is established that traditional rule-based models (such as First/Last Click, Linear, and U-shaped), while popular due to their simplicity, present significant limitations in the context of complex multichannel interactions. These models fail to consider the sequence, context, and interdependencies between touchpoints, resulting in a distorted understanding of the actual contribution of channels. Particular attention is given to Markov chains as a stochastic method for assessing channel impact, as well as to the Shapley value model derived from cooperative game theory. Both approaches demonstrate a stronger capacity to account for channel interactions, user journey context, and multichannel effects – substantially outperforming rule-based models in digital

marketing settings. The Shapley Values Attribution model was implemented in a Python environment using real-world data. This allowed for the reconstruction of detailed user journeys, the formation of channel coalitions, the calculation of the marginal contribution of each channel across all possible combinations, and the visualization of the results. As a result, the analysis identified the channels with the greatest marginal effect in driving conversions while avoiding the overvaluation of channels with high interaction frequency but minimal actual impact.

It is important to acknowledge that the findings presented in this study are derived from a single dataset; comparable approaches have been employed by other explorers (Mehta & Singhal, 2020; Ben Mrad & Hnich, 2024), who similarly conducted analyses on limited samples. To strengthen the external validity and generalizability of these results, future research should consider applying the proposed methodology to diverse datasets encompassing varying product verticals, temporal frameworks, and channel configurations. Such extensions would facilitate the evaluation of the model's robustness across different contexts and enhance confidence in the applicability of the conclusions drawn.

Notwithstanding the model's potential precision, critical questions remain concerning the practical interpretability of Shapley value-based attribution outcomes, particularly when juxtaposed with simpler, more conventional models favored by practitioners. Additionally, the feasibility of implementing this approach in small enterprises with constrained computational resources, alongside its limitations under conditions of fluctuating user behavior, warrants further investigation. Moreover, systematic comparisons with other publicly available empirical studies are recommended to enable a more comprehensive understanding of the influence exerted by individual marketing channels.

A comparative analysis of the results from rule-based models (Last Click, Linear Attribution) and the algorithmic Shapley-based approach confirmed that rule-based models tend to overly concentrate or oversimplify influence. In contrast, the Shapley model enabled an objective evaluation of channel contributions across different combinations, confirming its superior accuracy, flexibility, and predictive power in marketing analytics.

Based on the results, a meaningful interpretation of channel contributions was proposed. The roles of individual channels within the user journey were identified, key channels at different stages of the funnel were determined, and budget optimization opportunities were revealed. The findings not only confirmed the advantages of adaptive attribution models but also illustrated how accurate analytics can become a strategic asset in a world where every customer interaction matters. Future research will aim to expand the analysis by incorporating additional factors such as the temporal dynamics of interactions, acquisition costs across different channels, and user segmentation by behavioral and demographic characteristics. This will facilitate the development of more sophisticated and flexible attribution models that consider not only the contribution of channels to conversions, but also their effectiveness over time, across audience segments, and within budgetary constraints.

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theoretical background; Nikolay Penev – ideas; formulation or evolution of overarching research goals and aims; Maiia Pustovit – empirical data collection and validation, implementation of empirical research.

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МОДЕЛЮВАННЯ АТРИБУЦІЇ НА ОСНОВІ ДАНИХ У ЦИФРОВОМУ МАРКЕТИНГУ

Вступ. У сучасному цифровому середовищі маркетингові комунікації стали багатоканальними, персоналізованими та динамічними, що зумовлює зростаючу потребу у точному вимірюванні ефективності кожної взаємодії користувача з брендом. Традиційні правила маркетингової атрибуції, які надають усю цінність одній точці контакту, вже не забезпечують належного рівня аналітичної точності. У відповідь на ці виклики все ширше застосовують економіко-математичні методи, зокрема й моделі на основі ланцюгів Маркова та значень Шеплі, що дають змогу аргументовано й кількісно обґрунтовано розподіляти цінність між усіма каналами.

Методи. Методологія дослідження ґрунтується на поєднанні загальнонаукових і спеціалізованих методів. Зокрема, використано теоретичне моделювання, порівняльний аналіз, а також стохастичне моделювання (ланцюги Маркова) та теорію кооперативних ігор (значення Шеплі).

Результати. У цьому дослідженні вивчено проблему маркетингової атрибуції в цифровому середовищі, доведено обмеженість традиційних моделей та обґрунтовано переваги адаптивних підходів, таких як ланцюги Маркова та значення Шеплі. Практична реалізація та порівняльний аналіз моделі на основі значень Шеплі підтвердили її вищу точність і здатність об'єктивно оцінювати внесок кожного каналу, що дозволило сформулювати цінні рекомендації для оптимізації маркетингових стратегій.

Висновки. Розроблено та впроваджено модель атрибуції на основі значень Шеплі, що дає змогу враховувати маржинальний внесок каналів у всіх можливих комбінаціях взаємодій, на відміну від традиційних моделей маркетингової атрибуції, що засновані на правилах. Результати дослідження можуть бути використані компаніями для точнішого оцінювання ефективності маркетингових каналів, оптимізації бюджету та підвищення рентабельності інвестицій у цифрову рекламу.

Ключові слова: маркетингова атрибуція, цифровий маркетинг, атрибуція на основі даних, значення Шеплі, ланцюги Маркова, мультиканальна аналітика, Python.

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ECONOMIC GROWTH DRIVERS: EMPIRICAL FINDINGS FOR DEVELOPING EUROPEAN COUNTRIES

Background. The relevance of this article lies in the persistent importance of economic growth in developing economies as a central subject of modern economic research. The growing integration of global markets and rapid technological change have significantly influenced the pace and structure of development across countries. Identifying the fundamental drivers of growth is essential for shaping policies that ensure long-term stability and sustainable progress. The experience of countries that have successfully transitioned from developing to advanced status offers valuable empirical evidence. Examining these cases makes it possible to determine the most significant factors contributing to economic growth. In this context, the study of growth drivers in developing European economies acquires particular importance for understanding their prospects for accelerated and sustainable development.

Methods. The study applies a combination of theoretical analysis, comparative assessment, and regression modeling to provide a comprehensive examination of economic growth drivers.

Results. In this study, using empirical analysis, it was found that the most important factors of economic growth were the amount of investment in real assets, the effectiveness of public spending, and investment in science and technology. However, the quality of institutions and demographic changes require a deeper analysis, since their impact has been ambiguous.

Empirical analysis has shown that the significant factors of economic growth are the volume of investment in real assets, the rate of population growth, and the share of international trade in GDP. In contrast, the quality of institutions and spending on education and R&D require deeper analysis, since their impact is not observed in the short term.

Conclusions. Based on the analysis of theoretical models and empirical findings, the key factors that have the greatest impact on the growth rate of GDP per capita have been identified. Drawing on both the theoretical analysis and empirical results, practical recommendations were formulated for Ukraine's future economic strategy. Today, the urgent need to define and build a path to post-war recovery and further economic growth in Ukraine makes this research relevant.

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FUZZY COGNITIVE MAPS FOR HIGH-TECH COMPANIES' RESILIENCE MODELING

Background. Relevance. Modern high-tech companies are dealing with more uncertainty and a range of complex threats, such as cyberattacks, infrastructure disruptions, and personnel challenges. Building resilience in these businesses is now essential for the national economy. **Objective.** This study aims to develop a cognitive model for assessing the resilience of high-tech companies under complex threats based on fuzzy cognitive maps.

Methods. The fuzzy cognitive map (FCM) method combined with fuzzy DEMATEL was used to determine factor weight coefficients. An expert survey of 10 top managers was conducted to assess the relationships between factors. The agreement among experts was assessed using Kendall's coefficient of concordance ($W = 0.864$, $p < 0.01$). Impulse modeling was applied to analyze system dynamics.

Results. The resulting FCM, with weights determined through Fuzzy DEMATEL, identified cyber threats as the most critical negative factor (−0.32) and physical infrastructure as the most significant positive factor (+0.28) influencing overall company resilience.

Conclusions. The proposed model shows how different factors influence a company's resilience and helps managers set clear priorities. In practice, it can be used to model crisis scenarios and guide better resource allocation to strengthen business resilience.

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INTERNAL MARKETING AS A STRATEGIC TOOL FOR DEVELOPING INNOVATIVE AND MANAGERIAL POTENTIAL AND ENHANCING THE COMPETITIVENESS OF BUSINESS ENTITIES

Background. Internal marketing is now viewed as a comprehensive system of partnership-based relations that fosters the development of corporate culture, employee loyalty, and customer orientation. This approach increases employee satisfaction, reduces resistance to organizational change, promotes interdepartmental synergy, and contributes to the achievement of the strategic objectives of the economic entity. The relevance of this topic stems from the ongoing transformation of economic conditions, the growing significance of human capital, and the increasing necessity for strengthening internal organizational interactions.

Methods. To generalize the stages of internal marketing evolution and to formulate the authors' approach to defining it, the methods of induction and deduction, along with a comprehensive approach, were employed. To examine scientific approaches to the interpretation of internal marketing and to identify interconnections among elements of the personnel management system, methods of analysis and synthesis were used. Additionally, to construct a conceptual model of internal marketing as an integrated system of interaction, methods of abstraction, logical generalization, and a systemic approach were applied. The study's information base comprised scientific works by foreign and domestic scholars on service marketing, personnel management, organizational behaviour, and internal communications. It also included analytical materials and methodological sources reflecting contemporary approaches to implementing internal marketing in economic entities.

Results. The article substantiates the evolution of approaches to defining the essence of internal marketing within economic entities, as well as its role in shaping an effective personnel management system and influencing organizational behavior. It establishes that modern interpretations of internal marketing encompass not only activities related to attracting,

training, and motivating personnel but also the development of communication systems, the formation of a value set-up, corporate philosophy, and culture. The authors propose a definition of internal marketing based on the identified key principles, factors, and functions, and present a model of internal marketing for an economic entity. This model is based on elements of the classical marketing "4P" framework and encompasses components such as planning, communications, control, and reputation management, among others.

Conclusions. The conducted research enabled the authors to define internal marketing as an integrated system of partnership relations in human resource management. This system focuses on creating and maintaining a motivational climate and organizational working conditions within the economic entity to ensure customer orientation and employee loyalty. In this framework, employees not only perform functions aimed at improving service quality and meeting the needs and demands of the customers but also actively participate in implementing corporate philosophy, values, and strategies to achieve objectives and maintain a positive company image. A conceptual model of internal marketing is proposed as a human resource management mechanism that integrates motivational, communicative, organizational, and cultural components within the economic entity.

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MANAGERIAL AND FINANCIAL ASPECTS OF INNOVATIVE ACTIVITIES OF INTERNATIONAL COMPANIES: CASE ANALYSIS OF APPLE, GOOGLE, SAMSUNG, AND TESLA

Background. The relevance of this study lies in the analysis of innovations as a key factor for competitiveness under globalization, the examination of modern approaches to organizing innovation activities, and the specific features of implementing innovation strategies in leading transnational corporations. The aim of the study is to offer both a theoretical foundation and a practical analysis of the specific aspects of innovation management in international companies. The object of the study is the processes of managing innovation activities in international companies, while the subject of the study comprises the approaches and tools used to manage innovations in transnational corporations and other international business entities.

Methods. To achieve the stated aim, general scientific and specialized methods were employed, including generalization and systematization, case studies, comparative analysis, and content analysis.

Results. Based on open analytical sources, an assessment of the level of innovation activity of Apple, Google, Samsung, and Tesla revealed both commonalities and distinctions in their innovation models.

Conclusions. The guidelines for enhancing innovation management systems in international companies have been substantiated, with particular focus on proposing methods to improve adaptability, openness to change, and the integration of digital technologies into innovation development processes.

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DYNAMIC OF ESG PERFORMANCE AND RISK-RETURN CORRESPONDENCE FOR LARGE US COMPANIES: EMPIRICAL ANALYSIS OF THE DJIA INDEX BASKET

Background. Legislative and regulatory changes are reshaping the landscape of Environmental, Social, and Governance (ESG) principles. This is prompting companies to reassess their commitments and implement new business development strategies that align with sustainable development. At the same time, certain "anti-ESG" trends, primarily in the US, are creating uncertainty regarding ESG performance dynamics, and the risk-return correspondence dynamics also appear unstable. These developments motivated the study's purpose: to examine the dynamics of ESG and risk-return correspondence from 2019 to 2024.

This paper presents results on the dynamics of 10 ESG subindexes and the K-ratio indicator for the largest US companies from 2019 to 2024. We also analyzed the hypothesis concerning the correspondence between ESG performance and the investment risk-return ratio.

Methods. Employed methods include factual and comparative analysis, statistical techniques, correlation estimation, risk-return measurement, synthesis, and deduction.

Results. We estimated the dynamics of subindexes for 30 US companies from the Dow Jones Industrial Average (DJIA) index basket using statistical analysis of ESG scores. The subindexes exhibited convex upward trajectories, reaching their highest scores in the year when the COVID-19 pandemic began. Analyzing risk-return correspondence from 2019 to 2024 revealed persistent and significant changes in this ratio's value. A statistical analysis of the relationship between ESG scores and risk-return correspondence showed that there is no clear correlation between these two components. Therefore, it can be concluded that these two factors have distinct dynamics and that there is no clear relationship between ESG performance and market risk-return outcomes.

Conclusions. ESG principles are becoming an important component of sustainable business development; however, this process remains multifaceted and complex for large companies. The implementation of ESG scoring systems by several global rating agencies enables the identification and analysis of numerical patterns of this development. Current research focuses on analyzing the impact of ESG reporting on corporate financial and investment performance. Identifying such regularities will improve our understanding of the role and significance of ESG in the holistic analysis of corporate development.

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MIGRATION CHALLENGES AND GOVERNMENT POLICIES IN EU COUNTRIES AND UKRAINE AMID THE RUSSO-UKRAINIAN WAR

Background. This article is part of the project No. 101132435 – SKILLS4JUSTICE Topic: HORIZON-CL2-2023-TRANSFORMATIONS-01-03 and presents a comprehensive analysis of current migration processes in Ukraine and the multifaceted challenges they pose for the European Union. Since 2014, and especially following the full-scale Russian invasion in 2022, Ukraine has experienced one of the largest migration waves in Europe since World War II. The study highlights the socio-economic, educational, and political aspects of these migration flows, considering both internal displacement and international migration trends. The research examines the composition, motivations, and regional distribution of Ukrainian migrants in EU member states, emphasizing variations in labor migration, forced displacement, and student mobility. Special attention is given to the gender, age, and professional characteristics of migrants, as well as structural challenges they face, such as access to education, language barriers, labor market integration, and social inclusion.

Methods. The study employs a combination of statistical analysis, policy review, and thematic case studies across selected EU countries to provide an evidence-based perspective on migration dynamics and policy responses.

Results. The article examines the consequences of migration dynamics for the EU, including demographic pressures, labor shortages in certain sectors, strain on public services, and the need to adapt national and EU-wide migration policies. It analyzes how host countries address the integration of Ukrainian refugees and labor migrants, assessing the preparedness of education systems, labor markets, and social infrastructure to cope with a sustained influx. The paper evaluates the Ukrainian government's strategies for migration management and its cooperation frameworks with European institutions. It discusses potential long-term impacts of migration on Ukraine's human capital, including brain drain and the loss of skilled labor, alongside opportunities for circular migration and diaspora engagement.

Conclusions. Based on the findings, the article offers data-driven recommendations aimed at building more coherent, inclusive, and sustainable migration policies. These results are intended to support the formulation of informed policies in both Ukraine and the EU, within the broader context of regional stability, educational development, and socio-economic resilience.

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MATHEMATICAL MODELING OF INFLATION PROCESSES IN THE ECONOMY USING DIFFERENTIAL EQUATIONS WITH FRACTIONAL DERIVATIVES

Background. When studying rapidly changing inflationary processes in economics, theoretical methods based on ordinary differential equations or partial differential equations are often used. However, as demonstrated in this paper, in certain cases it is more appropriate to use the apparatus of differential equations with fractional derivatives. This is due to the presence of various types of nonlinearities in functional relationships within inflationary processes, the influence of parameter values from previous time points on current values, the existence of scaling relations, and so on. In fact, all these characteristics are inherent to fractional calculus.

Methods. The article is devoted to the application of differential equations with fractional derivatives of Caputo for the analysis of inflationary (deflationary) processes in the economy, based on the method of measuring inflation using the consumer price index, which takes into account changes in prices for a certain set of goods and services. This is demonstrated by changes in the specified index over finite time periods.

Results. It is shown that the use of fractional order differential equations can be useful for building flexible tools for forecasting inflation/deflation processes. The relationship between the inflation rate and the unemployment rate is also investigated.

Conclusions. It has been established that the change in the fractional derivative index in theoretical models of economic processes allows describing different regimes of price dynamics – from moderate inflation to galloping and hyperinflation, as well as complex deflationary scenarios. The appearance of negative values of price indices for individual goods can be interpreted as a consequence of their excess production, which leads to a loss of market value. The proposed method of using differential equations with fractional values of the order of derivatives provides an expansion of the possibilities of modeling a wide range of economic processes.

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INTEGRATION OF CIRCULAR ECONOMY AND RESILIENCE PRINCIPLES INTO STATE ANTI-CRISIS POLICY AND CORPORATE STRATEGIES

Background. Modern global challenges – from climate change to armed conflicts – have intensified the search for new economic models capable of combining the objectives of sustainable development with the enhancement of the resilience of societies and economies. The purpose of the study is to systematize theoretical approaches to the formation of new economic models of sustainable development and resilience, to determine their potential for strengthening the economic security of the state and enterprises, as well as to substantiate the possibilities of integrating the principles of the circular economy and resilience into state anti-crisis policy and corporate strategies using Ukraine as a case study. At the core of the research hypothesis lies the assumption that the spread of sustainable and resilient development practices among Ukrainian enterprises directly influences the country's economic security, shaping its ability to withstand military and global risks

Methods. Analysis and synthesis, generalization; structural and functional analysis method; graphical and tabular methods.

Results. In the course of the study, a typology of new economic models (green, circular, frugal, solidarity, creative, etc.) was carried out, and their potential to ensure resilience and post-crisis economic recovery was analyzed. Particular attention was paid to the circular economy principles, which are considered an institutional basis for strengthening anti-crisis regulation and

long-term economic security. The empirical part of the study is based on the analysis of sustainable development practices of the 22 largest Ukrainian enterprises from six industries, which demonstrate high adaptability during wartime. Among the most widespread practices are employee and community support, assistance to the Armed Forces of Ukraine, as well as ecological modernization of production. On this basis, key components of sustainable development that directly affect the economic security of the state were identified, and indicators were proposed for assessing the contribution of business to ensuring resilience.

Conclusions. *The results confirmed the research hypothesis: sustainable development practices in wartime strengthen the economic security of the state and form the foundation for inclusive post-crisis recovery. The study combines the systematization of theoretical models with an applied analysis of corporate strategies, which ensures its scientific novelty and practical significance. Prospects for further research are related to the development of integrated methodologies for assessing economic resilience, digital support for circular practices, and the harmonization of Ukrainian sustainability standards with those of the European Union.*

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MEZZANINE FINANCING OF UKRAINE'S ENERGY INFRASTRUCTURE IN THE POST-WAR RENEWAL

Background. The Government of Ukraine has developed the Energy Strategy up to 2050, which aims to strengthen energy security and resilience and introduces targets for energy efficiency, environmental safety, reducing carbon emissions, etc. Post-war recovery combined with simultaneous modernization of Ukraine's energy sector will require the mobilization of significant financial resources, highlighting the importance of examining advanced global experience in attracting investment to energy infrastructure. The aim of the article is to substantiate promising methods of financing energy facilities for their implementation and application in the Ukrainian economy during the post-war renewal period.

Methods. Employed in the study include factual and situational analysis, synthesis, deduction, systems approach method, and theoretical generalization.

Results. The article analyzes global experience in applying and combining methods of financing energy infrastructure. It formulates the key principles for mobilizing investment in modern energy. The study provides analytical conclusions with justifications regarding the prospects and relevance of implementing and applying mezzanine financing for the post-war renewal of Ukraine's energy sector. The most priority and optimal mezzanine forms of attracting investments to the energy sector are identified.

Conclusions. The study distinguishes the key principles for mobilizing investment in the energy sector, namely: consideration of energy security and socio-economic stability aspects, mobilization of non-state financing, minimization of the cost of capital, harmonization of the project's cash flows, fair risks and returns allocation. Based on global experience, a comparison of primary capital mobilization methods for energy infrastructure (from the state/IFIs, equity, debt, mezzanine) is performed. The prospects and relevance of mezzanine financing for implementation and application in the Ukrainian economy are substantiated. The most optimal forms of mezzanine financing for the energy sector are identified as securitization with tranching and subordinated debt financing. It is determined that Ukraine's institutional framework for these capital raising instruments has the potential for improvement and represents a promising direction for further researches. The study recommends the prompt implementation and institutionalization of mezzanine financing in the Ukrainian economy.

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STRATEGY FOR INVESTMENT LEADERSHIP OF THE TERRITORIAL COMMUNITY: METHODOLOGICAL APPROACH TO EVALUATION

Background. The article substantiates the necessity of strengthening the competitiveness of the territorial communities of Ukraine through a rethinking of their investment leadership strategy with the aim of ensuring sustainable competitive advantages. The dynamic conditions of the functioning of the external and internal environment of the territorial communities of Ukraine necessitate the improvement of the methodological tools for assessing their investment attractiveness. The purpose of

this article is to develop a methodological approach to the assessment of the level of investment attractiveness as the dominant integral indicator in the investment leadership strategy of the Irpin city territorial community.

Methods. The sources of data for the development of the methodological approach were the author's empirical research and the experience of participation in the expert group on the development of the Post-war Development Strategy of the Irpin city territorial community for 2025–2035. In this work, a combined approach was applied on the basis of financial and general methods, grounded in expert assessment of a number of structural blocks. For this purpose, the most optimal and significant initial parameters were proposed and analysed: economic potential and competitive conditions; infrastructure and environment; administrative support of entrepreneurship; development of the socio-economic sphere; and regulatory support for community development. The parameters were given substantive characteristics, assigned a coefficient of comparative significance, determined a coordinated final assessment, and the distance of the target indicator. According to the developed qualitative evaluation scale of the values of the integral indicator of investment attractiveness, the ranking of these parameters was carried out by average values. Averaged values of the assessment parameters of investment attractiveness of the Irpin city territorial community were obtained by separate structural blocks.

Results. The results of the assessment showed that the most attractive factors determining investors interest in investing capital in the territorial community of Irpin and its conglomerate are the prospects and substantiation of the Community Development Strategy with a time horizon of certainty until 2035, on which a group of domestic and international experts is currently working intensively; the available qualitative results of the implementation of the Program of socio-economic and cultural development of the Irpin city territorial community; the provision of equal opportunities for participation in public procurement procedures; resource and information support for entrepreneurship; transparency of permitting procedures in construction; consideration of public opinion in addressing issues of planning and development of territories; the substantiation and quality of the urban planning concept, as well as the favorability of the competitive environment for the entry of new entrepreneurs into the market.

Conclusions. Such components as the level of development of the industrial production sector and the existing economic potential of the community, the effectiveness of measures of financial, credit, and investment support for entrepreneurship, and the formation of favourable conditions for the realisation of the entrepreneurial potential of the Irpin city territorial community require substantial attention to enhance investment attractiveness.

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GENDER COMPONENT OF THE RISKS OF THE BUDGET PROCESS IN UKRAINE

Background. This article is devoted to the study of gender aspects of the risks of the budget process in Ukraine, particularly the implementation of gender budgeting, as well as the assessment of risks that arise during the implementation of management decisions at all stages of the budget process of public authorities in Ukraine.

Methods. To carry out an in-depth analysis of the scientific problem under study, the article uses general scientific and special methods, including comparison, specification, typology, etc.

Results. The article presents the results of the analysis of the institutional and legal environment of gender aspects of the risks of the budget process at the state level. Following this analysis, the authors provide a list of risks at each stage of the budget process and possible consequences of failure to consider the gender aspects of these risks.

Conclusions. Based on the study, the authors provide examples of risks at all stages of the budget process regarding gender aspects, characterize them, and emphasize the need to continue developing in-depth methodological support for assessing the risks of the budget process concerning gender aspects at all stages of its implementation by the state authorities of Ukraine.

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KEY TRENDS IN GOVERNING UKRAINE'S ENERGY SECTOR IN THE CONTEXT OF MILITARY AGGRESSION

Background. *The energy sector of Ukraine is a critical component of the national infrastructure. In Ukraine, this issue is especially relevant under the influence of military aggression, since its facilities in all sectors (from mining to electricity generation and oil refining) are being constantly destroyed. The restoration of the energy sector of Ukraine and its further development require new approaches to its management and the application of new technologies to increase the efficiency of resource use. The purpose of the study is to identify key trends and develop approaches to the intensive use of Ukraine's energy resources using the latest technologies. The task of the study is to determine the prospects for using cogeneration to rebuild the energy sector of Ukraine. The object of the study is approaches to the intensive use of energy resources. The subject of the study: the main tools for rebuilding the energy sector of Ukraine.*

Methods. *The methodological basis of the study is general scientific and special methods of scientific knowledge, in particular, theoretical and methodological analysis of modern literature on the development of the energy sector, and documents of world organizations in the energy sector. The method of analysis and synthesis was used to generalize and provide a unified approach to highlighting the advantages and disadvantages of the above-mentioned tools for rebuilding the energy sector. SWOT and PESTEL analyses were also used to determine the advantages and disadvantages of using cogeneration as a tool for rebuilding the energy sector of Ukraine.*

Results. *The study showed that significant destruction in the energy sector of Ukraine requires the application of new strategies for its development. Damage to electricity generation facilities requires their restoration on the principles of low-carbon technologies, and attacks on oil and gas fields led to the need to restore previously preserved sources of hydrocarbons. It was determined that the use of deposits that were closed due to unprofitability requires the transition to new, more modern technologies, which will allow for an increase in the resource base of hydrocarbons and, using cogeneration of energy, to solve the problem of energy independence and ecology.*

Conclusions. *The introduction of cogeneration in the current conditions and war will allow attracting additional investments to increase the extractable reserves of oil and gas, maintain hydrocarbon production at the current level to increase electricity production, achieve energy stability and autonomy, save fuel, reduce the country's energy dependence, solve environmental safety, etc.*

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HOUSEHOLD DEPOSITS AND DEPOSIT GUARANTEE SCHEMES DURING CRISES IN UKRAINE

Background. Ensuring the stability of the banking system remains a key challenge during periods of economic and geopolitical crises. In Ukraine, the deposit guarantee system consists of both explicit and implicit components. While the explicit mechanism is represented by the Deposit Guarantee Fund (DGF), the implicit component reflects household trust in the state's role in protecting deposits, especially during force majeure events. This study aims to evaluate deposit stability in Ukrainian banks during crises.

Methods. The study applies descriptive statistical analysis of deposit trends disaggregated by bank ownership (state-owned, foreign, private) and deposit currency (national vs. foreign) from 2013 to 2024. The analysis includes chain growth rates and deposit structure indicators (demand vs. time deposits) during key crisis phases: the 2014 military aggression, the COVID-19 pandemic, and the 2022 full-scale invasion.

Results. During the analyzed period, the structure of household deposits underwent significant transformations. First, the ratio between time deposits and demand deposits in the national currency declined from 2.63 to 0.52, while in foreign currency it dropped from 6.77 to 0.56. Second, households increasingly favored government-owned banks, while foreign banks retained a moderate level of trust and private banks showed greater volatility. Both explicit and implicit deposit guarantees played a role in maintaining depositor confidence. However, during major shocks, the implicit guarantee system proved particularly influential.

Conclusions. In Ukraine, deposit analysis must consistently account for the currency structure due to persistent devaluation risks and the varying levels of depositor trust associated with different forms of bank ownership. A comprehensive understanding of deposit behavior under stress requires evaluating both explicit and implicit protection. While the DGF offers a solid foundation, it must be supported by credible implicit guarantees and effective crisis management frameworks.

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p. 134-140

RISK ANALYSIS IN THE SYSTEM OF OTHER (NON-PRICE) METHODS FOR EVALUATING TENDER PROPOSALS

Background. *Non-price criteria are an important strategic tool for achieving social, environmental, and economic objectives. However, their practical application may be accompanied by a number of problems and risks. This study aims to identify the main problems and risks associated with the use of non-price evaluation criteria and to develop well-grounded recommendations in the context of establishing effective safeguards to neutralize or mitigate these risks.*

Methods. *The study employed the special legal method for analyzing the regulatory framework, case analysis to examine specific procurement examples, the statistical method for processing empirical data, as well as a systems approach to generalize findings and formulate reasoned proposals.*

Results. *An analysis was conducted of the regulatory framework, statistical data, and individual practical cases related to the use of non-price criteria in evaluating tender proposals in Ukraine and EU member states. The research showed that, despite the formal recognition of the advantages of this tool, its practical application remains limited due to legal uncertainty, low awareness among contracting authorities, and the risk of abuse. Even the positive experience of European countries demonstrates that the active use of non-price criteria does not always guarantee successful outcomes and, in some cases, leads to distorted bidding results. At the same time, under conditions of proper regulation and effective procurement oversight, non-price criteria can become a powerful tool for shaping a transparent, results-oriented, and socially responsible procurement system.*

Conclusions. *Public procurement practice in Ukraine demonstrates a low level of application of non-price evaluation criteria, which is driven by legal ambiguity and the risk of abuse. To improve the situation and encourage more frequent use of non-price criteria by contracting authorities, it is essential not only to adopt European approaches but also to ensure appropriate conditions for their implementation through comprehensive reforms.*

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p. 141-149

CONSUMER BEHAVIOUR MODEL FOR ORGANIC PRODUCTS: AN EMPIRICAL STUDY OF THE UK MARKET

Background. *The growing global demand for organic products is driven by the intensification of environmental problems and a shift in consumer priorities toward safe and sustainable goods. The organic products market is shaped by a combination of economic, social, and cultural factors, which calls for a detailed examination of consumer behavior models in international markets. The purpose of this study is to enhance theoretical approaches and develop practical recommendations for applying consumer behavior models as a basis for effective strategies for businesses operating in international organic markets, thereby promoting the sustainable development of Ukraine's economy. The object of the study is the economic relations between producers and consumers in international organic markets, while the subject of the study is the theoretical and methodological aspects of forming consumer behavior models in these markets.*

Methods. *The research is based on the comprehensive application of general scientific methods (analysis and synthesis, induction and deduction, analogy and comparison, classification, systematization, quantitative and statistical analysis, etc.) and specific scientific methods (hypothetical, theoretical modeling, and visual-graphical methods). This approach made it possible to combine theoretical analysis with empirical observations to achieve the research objectives.*

Results. *It was found that none of the analyzed consumer behavior models in the domestic or international economic literature fully captures all aspects of the behavior of organic product consumers. Therefore, a comprehensive model was developed that integrates cognitive, emotional, and value dimensions in shaping consumer intention and translating it into behavior. This model served as the foundation for developing a strategy to promote the company "Danube Agrarian" in the UK market. In addition, the study identified positive social and environmental effects of the organic sector's development on Ukraine's economy.*

Conclusions. *The proposed model serves as a tool for predicting consumer behavior and can be used as a basis for developing strategies to promote products in international markets. The results obtained have practical significance for Ukrainian producers of organic products and will contribute to enhancing Ukraine's competitiveness in the global market and advancing its transition toward a sustainable development model.*

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CURRENT CHALLENGES IN FINANCING HIGHER EDUCATION

Background. The key foundation for the qualitative development of a country's economy lies in the level of advancement of its education and science. Amid current challenges, this is critically important for the country's survival. The state of education and science in Ukraine largely depends on the availability of funding resources, the search for successful international models, and their implementation and adaptation to the country's present realities. It is also essential to apply rigorous criteria when prioritizing funding for education and science. The aim of this study is to analyze the state of higher education financing in Ukraine, its relationship with the Human Development Index, and to explore possible trajectories for further development of this sector.

Methods. To achieve the research objectives, the study employed methods of analysis and synthesis (generalization and identification of key aspects), statistical analysis (processing data on the current state of higher education financing), and graphical methods (for visual representation of the studied processes).

Results. The article analyzes the financing of higher education as a critically important factor in developing Ukraine's knowledge-based economy. It identifies the link between education funding, the Human Development Index, and the country's innovation potential. The paper examines international practices—specifically, Germany's competitive grant-based funding model and Israel's strategy for building a "startup nation." It highlights key domestic challenges: low efficiency of resource use, a lack of innovative financial mechanisms, and weak integration of science into the global arena. The need for infrastructure investment and support for high-potential universities is substantiated.

Conclusions. The study concludes that the development of a knowledge economy requires high-quality education and effective financing, including transparent use of public funds and encouragement of student loan systems. Major challenges include the absence of innovative financial mechanisms, weak business investment activity, and poor integration of Ukrainian science into the global research space, all of which reduce resource efficiency. A breakthrough in education demands investment in universities' infrastructure, optimized budget spending, and support for institutions with strong development potential.

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QUANTIFYING THE INTERNATIONALIZATION CAPACITY OF SMALL AND MEDIUM-SIZED ENTERPRISES

Background. The article examines the problem of involvement of Ukrainian small and medium-sized businesses in foreign economic activity (FEA) in the context of deep structural changes caused by martial law, the transformation of the global economy, and digitalization. The relevance of the topic is driven by the need to formulate an effective policy to support small and medium-sized businesses to boost exports, imports, and integration into international markets, which are critical to the country's economic recovery. The purpose of the study is to quantify the export capacity, import activity, and overall involvement of enterprises of different sizes in FEA, as well as to identify barriers and formulate measures to enhance the internationalization of small and medium-sized businesses.

Methods. The methods of statistical analysis, comparative approach, normalization of indicators (min-max method), and construction of integral indices are used in the study. An empirical analysis of the statistical data of the State Statistics Service of Ukraine for 2016–2023 is carried out.

Results. The results show that micro and small enterprises have increased the efficiency of export and import activities, especially under martial law, while large enterprises have lost momentum. The indices of export capacity, import activity, and overall involvement in FEA were constructed, which allowed us to establish the leadership of medium-sized enterprises in terms of export capacity in 2023 and the growth of import intensity of microenterprises. Barriers related to lack of funding, certification difficulties, and low digital readiness have been identified.

Conclusions. The practical value of the study lies in the proposed tools for assessing the participation of small and medium-sized businesses in FEA and recommendations for supporting their internationalization.

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ASSESSMENT OF THE COMPETITIVE ENVIRONMENT OF IT COMPANIES

Background. Ukraine's IT services market has remained a dynamic and export-oriented segment of the economy during the full-scale war, while undergoing consolidation, exits, mergers and acquisitions (M&A), and restructuring processes. Small and medium-sized enterprises (SMEs) are gaining visibility, yet competitive conditions remain ambiguous due to business groups comprising multiple legal entities. This study focuses on Ukraine's IT services market, examining the competitive environment and structural market asymmetries from 2022 to 2024. It aims to evaluate the level and dynamics of competition by analyzing market concentration and structural asymmetries during this period.

Methods. A system-structural approach is applied, using concentration metrics for firms classified under Classifier of Types of Economic Activities (KVED) sections 62 and 63. Indicators include the Herfindahl–Hirschman Index (HHI), concentration ratios (CR₃, CR₅), the Gini Index, the Entropy Index, the Linda Index, and variance-based measures. Market shares are calculated from revenue; the SME share in total market revenue is also tracked. Descriptive statistics are complemented by comparative analysis across 2022–2024 on a research sample of 411 companies (13 large), with particular attention to the gap between the number of legal entities and verified active companies.

Results. The market exhibits complex corporate structures: 8.6 thousand legal entities provided IT services in 2024, but only 2,118 companies were verified as active. HHI fell from 433.68 (2022) to 170.86 (2024), signalling stronger competition. CR₃ declined from 26.18% to 17.77%, and CR₅ from 34.13% to 23.31%; the SME revenue share rose from 52.7% to 62.4%. Distribution-sensitive measures reveal a hybrid structure: high entropy (E = 5.09) and low variance indicate broad participation, whereas the Gini Index (0.601), the Linda Index (169.2%), and the Lorenz curve point to a dominant core in the upper segment. By business model, outsourcing firms prevail (47% in 2024), followed by product (31%), mixed (19%), and outstaffing (3%).

Conclusions. Ukraine's IT services market is moving toward a more competitive, decentralized configuration while an oligopolistic core persists. The simultaneous rise of SMEs and the weakening of top players' shares reduces monopolization risks, enhances resilience, and suggests growing value-added potential. Policy should balance SME entry and scaling with support for high-value, export-oriented capabilities through cooperation with market leaders. The proposed methodology can be applied to other high-tech markets, while future research should examine the links between concentration dynamics, financial stability, and the role of business models in shaping the competitive environment.

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ASSESSMENT OF THE PRIORITY OF SUSTAINABLE DEVELOPMENT GOALS IN THE CONTEXT OF CURRENT CHALLENGES FOR UKRAINE

Background. The global coronavirus pandemic, combined with economic, social, and environmental challenges during a full-scale invasion, has had a profoundly negative impact on the system of interaction among businesses, consumers, partners, and stakeholders. The modern business landscape requires coordinated actions by the global community to establish balance in the domestic business ecosystem, interacting with international donors and potential investors. A full-scale invasion is a catalyst for the sustainability of domestic businesses. It is the ability to ensure economic survival while simultaneously preserving social responsibility and the environmental interests of natural ecosystems. The goal of the study is to develop an algorithm for conducting a comprehensive assessment of the priority of sustainable development goals. We substantiate a methodological support. According to this approach, we group the goals by economic, environmental, and social indicators, generalizing the criteria for their selection in different periods (before and during the war), and identifying the changes that have occurred.

Methods. One of the objectives of the study is to determine the priority of implementing sustainable development goals in different periods (before the war and during the war) and identify the changes that occurred. Solving the problem of determining the priority of implementing these goals at a practical level can be reduced to their ranking within each component using multi-criteria analysis methods. They are widely represented in management theory and practice. To solve the research tasks, we use methods for evaluating alternatives. They are TOPSIS, SAW, COPRAS.

Results. The modern challenges that Ukraine faces today have somewhat changed the priority of implementing sustainable development goals across all components of sustainable development: by the economic component, "peace and justice" and "partnership for sustainable development" are becoming relevant for Ukraine; by the social component, the goals of "decent work and economic growth" and "quality education" are the first; by the environmental component, the goals of "affordable and clean energy" and "clean water and adequate sanitation" became prioritized.

Conclusions. The war in Ukraine has brought to the fore the issue of theoretical discourse around the priority of sustainable development components for our state. But the war did not change the desire of entrepreneurs to solve their economic problems, taking into account the development of the concept of sustainable development, solving social issues, and respecting the environmental interests of society.

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DATA-DRIVEN ATTRIBUTION MODELING IN DIGITAL MARKETING

Background. In the contemporary digital environment, marketing communications have evolved into multi-channel, personalized, and dynamic interactions, necessitating an increasingly precise quantification of the efficacy of each user touchpoint with a brand. Conventional rule-based marketing attribution models, which exclusively assign value to a singular touchpoint of contact, no longer yield the requisite level of analytical granularity. In response to these methodological challenges, advanced

economic and mathematical methodologies, notably models predicated on Markov chains and Shapley values, are progressively being deployed to facilitate a rigorously reasoned and quantitatively justifiable allocation of value across all contributing channels.

Methods. The research methodology is based on a combination of general scientific and specialized methods. Specifically, it utilized theoretical modeling, comparative analysis, as well as stochastic modeling (Markov chains) and cooperative game theory (Shapley values).

Results. This research rigorously investigated marketing attribution in the digital environment, demonstrating the inherent limitations of traditional rule-based models and substantiating the superior efficacy of adaptive approaches, particularly Markov chains and Shapley values. The empirical implementation and comparative analysis of the Shapley value model confirmed its enhanced precision and capacity to objectively quantify each channel's contribution, leading to actionable insights for strategic marketing optimization. This study provides a robust framework for understanding multi-touch attribution, emphasizing the critical role of data-driven methodologies in contemporary marketing analytics.

Conclusions. The work is relevant for marketing analysts and digital strategy teams, as it presents a comparative analysis of rule-based and algorithmic attribution models and offers practical solutions for campaign optimization. The Shapley Value model was implemented in Python and tested on real-world marketing data. The practical value lies in the ability to use the results for better budget allocation, identifying undervalued channels, and increasing return on marketing investment (ROMI).

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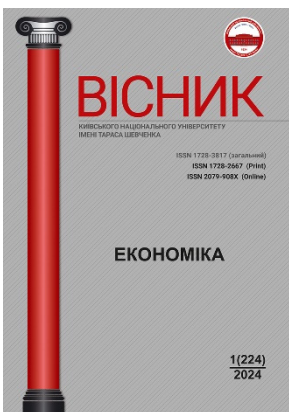
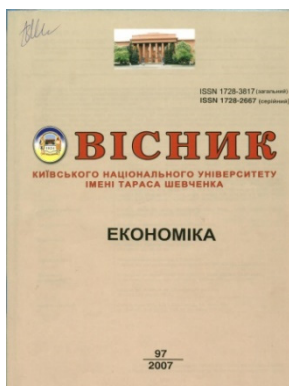
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