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Адреса редакції:
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 13, м. Київ, Україна
Тел.: +38(044)-258-42-63
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Editors office address:
National University of Life and Environmental Science of Ukraine
03041, 13 Heroiv Oborony Str., Kyiv, Ukraine
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E-mail: info@economicscience.com.ua
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Mykola Ilchuk*
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0001-5129-6110

Lyudmyla Berezovska
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-2782-032X

Organisational and economic aspects of production and sale of niche crops

Abstract. Despite the significant advantages of producing niche crops, producers often face several challenges, such as imbalances in supply and demand, high resource intensity and a significant share of intangible costs, which complicate large-scale implementation and require in-depth scientific analysis to find effective solutions. The study aimed to develop and substantiate an economic mechanism for the production and sale of niche grain crops. In the course of the research, the following scientific methods were used: data collection and analysis, bibliographic method, method of economic analysis, modelling and logical generalisation. The study provided a comprehensive assessment of the current state of production and sales of niche cereals in Ukraine, namely: buckwheat, rye, oats, millet, sorghum and rice. The analysis included estimates of area, gross harvest, yield, domestic consumption, imports and exports. The study showed a significant reduction in the area under niche grain crops in 2022 caused by military operations in Ukraine. The area under rice decreased by 93.8%, sorghum by 76.7%, millet by 55.8%, rye by 47% and oats by 19.1%. The study calculated the total normative food requirement for the production of niche cereals and concluded that the food requirement for rye bread (20.3%) and rice (12%) produced in Ukraine is insufficiently met. An assessment of imports of niche cereals showed that rice traditionally accounted for the largest share of imports: 81.18% in 2015, 82.39% in 2022 and 98.76% in 2023. Based on the results, an economic mechanism for the production and sale of niche crops, including resource provision, production organisation, logistics, marketing, financial analysis, efficiency control and state regulation, was compiled. The results of the study are of practical value for producers of niche crops seeking to diversify their operations, adapt to market and climate change, and increase the economic efficiency of production and marketing

Keywords: niche crops; innovative diversification strategies; exports; imports; marketing; logistics

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*Corresponding author

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INTRODUCTION

The production of niche crops helps diversify the agricultural sector, reduce dependence on traditional products, adapt to market and climate change, and increase export potential and economic efficiency. Despite the prospects of niche grain production, producers often face several challenges caused by imbalances between supply and demand, which lead to financial losses due to unprofitable sales of products, as well as difficulties in scaling up production due to high resource intensity and a significant share of intangible components in the cost of production. Given these features, there is a need for a deeper study of the problems associated with the production and sale of niche cereals and the justification of ways to overcome them.

The issue of niche crop production is becoming particularly relevant in the context of current challenges, including climate change and economic instability. In this regard, most researchers and practitioners define niche crops according to the following key criteria: underdevelopment of the relevant market, excess of demand over supply, low level of competition in the production sector, high purchase prices, significant profitability of cultivation, and the possibility of producing several value-added products from niche crops.

Scientists also concluded that niche crops are promising as a direction of production diversification, which is of interest to both small farms and large agricultural companies, as well as the importance of producing these crops for the formation of a set of economic, environmental and social effects. In particular, V. Tomashevskyi (2024) noted that in modern conditions, diversification of agricultural production through the cultivation of niche crops is of relevance, as it reduces the risks of losses associated with the shortage or death of traditional crops, as well as improve soil conditions through crop rotation diversification. N. Vasylieva & D. Nazarenko (2025) argued that diversified sustainable production will significantly reduce the risks of operating in the agricultural sector during wartime.

The study by T. Mirzoieva *et al.* (2024) revealed in detail the potential and economic importance of niche crops in the example of oats and millet due to their inherent advantages in economic, environmental, agrotechnical and social terms, multifunctionality and the possibility of producing a variety of products with high profitability. The importance of implementing a strategy for diversifying the production activities of agricultural producers was noted by M. Ilchuk *et al.* (2023b). Following the study, diversification in the agricultural sector will ensure the sustainable development of the industry, as this strategy can be used to reduce operational risk, achieve increased financial synergies, stabilise revenues, increase credit opportunities, and change the profile of the enterprise.

Some scientific studies addressed factors that may affect the sale of niche crops. In particular, A. Dibrova *et al.* (2024) analysed the impact of the cost of mineral fertilisers on the development of the rye market and found that an increase in the cost of mineral fertilisers by 50%, 100% and 150% did not affect the average yield, harvested area and gross harvest of this niche crop. A.V. Kucher *et al.* (2021) identified the factors that affect the export potential of niche crops in the context of sustainable development of enterprises and regions. The researchers divided them into natural (soil fertility, land resources, climatic conditions) and anthropogenic (efficiency of production and sales management in an unstable market environment). The interaction of these factors determines the level of efficiency and competitiveness, which directly affects the export of niche products.

The environmental aspect related to the adaptation of the agricultural sector to climate change was studied by W.L. Carrasco-Chilón *et al.* (2023). The study analysed rye as a dual-purpose crop and concluded that due to its high nutritional value and yield, it can be grown for livestock feeding in acidic soil and lack of precipitation, and for grain production in the rainy season. B. Brockmueller *et al.* (2022) proposed an innovative approach to niche cereal cultivation, which consists of using winter rye sown in spring as a living mulch for weed control in organic cereal systems.

Despite a significant number of scientific studies on the production and sale of niche crops, the issues of improving the efficiency of these processes remain insufficiently studied.

In particular, the aspects of optimisation of economic processes, improvement of the sales system, adaptation to market conditions and introduction of innovative approaches to increase the competitiveness of niche crop products require further analysis. The study aimed to develop and theoretically substantiate an economic approach to the production and sale of niche grain crops.

MATERIALS AND METHODS

The following methods were used to conduct the study: data collection and analysis (desk research), bibliographic method, method of economic analysis, modelling and logical generalisation. The desk research method involved the use of data from the State Statistics Service of Ukraine for 2015, 2020-2023, concerning the commodity structure of Ukraine's foreign trade (Commodity structure of foreign trade..., 2016; 2021; 2022; 2023; 2024), areas, gross harvests and yields of agricultural crops by type and by region (Areas, gross harvests and yields of agricultural crops..., 2021; 2022; 2023; 2024), harvesting of agricultural crops, fruits, berries and grapes in the regions of Ukraine in 2015 (Harvesting of agricultural crops..., 2016); statistical data published by Statista for the 2021/22-2023/24 marketing years (Domestic consumption of grains in Ukraine...., n.d.).

To calculate the volume of gross harvest of niche cereals (rye, oats, rice, buckwheat, millet) to meet the food needs of the Ukrainian population, the Resolution of the Cabinet of Ministers of Ukraine No. 780 (2016), data from the State Statistics Service of Ukraine on the population of Ukraine (estimated) as of 1 February 2022 (Population by region..., 2022) and cereal (flour) yields (Grain technology, n.d.) were used. The data obtained as a result of the desk research became the basis for economic analysis, which not only identified key trends and patterns, but also substantiated scientific hypotheses and formulate reasonable conclusions. In addition, the results of the analysis became the basis for further research on the development of effective strategies and recommendations for practical implementation.

To collect and analyse the data, the bibliographic method was used, which involved the processing of various sources of information listed in the list of references, including scientific articles (Demianenko, 2024; Tomashevskyi, 2024), regulations (Resolution of the Cabinet of Ministers of Ukraine No. 780, 2016; Resolution of the Cabinet of Ministers of Ukraine No. 1424, 2021; Resolution of the Cabinet of Ministers of Ukraine No. 886, 2021) and a statistical collection (Harvesting of agricultural crops..., 2016). the method provided comprehensive data on the production of niche crops. This method was used in the introduction and discussion section to identify promising areas for further research, as well as to emphasise the uniqueness of the interpretation of the results in the context of modern scientific achievements.

The method of economic analysis was used to identify patterns and trends in the production and sale of niche crops in Ukraine. It was used to analyse the dynamics of sown areas, harvested areas, gross yields, and yields of niche crops in Ukraine, as well as domestic consumption of these crops, exports and imports. The modelling method was used to build an economic mechanism for the production and sale of niche crops, and the method of logical generalisation was used to draw conclusions and develop proposals. These methods were used to develop an economic mechanism for the production and sale of niche grain crops and to substantiate proposals for markets for their sale.

RESULTS AND DISCUSSION

By 2022 (Fig. 1), Ukraine was actively developing the production of grain crops that can be classified as niche crops due to their small sown areas, which do not exceed 150-200 thousand hectares, according to the study. These crops include rye, oats, rice, sorghum, buckwheat and millet. Traditionally, they were substantial in the national agriculture, meeting food, feed and industrial needs both in the domestic market and in export trade. However, starting in 2022, due to the hostilities in Ukraine, there has been a significant reduction in the area under these crops, as shown in Figure 1.

In 2023, the area under buckwheat increased only compared to 2015. This is due to its strategic importance for the domestic market, as well as the introduction of state support to produce this crop. The Procedure for the Use

of Funds Provided for in the State Budget for Financial Support of Agricultural Producers (Resolution of the Cabinet of Ministers of Ukraine No. 77, 2017) defined the mechanism for using funds from the Ministry of Agrarian Policy under the programme 2801580 "Financial Support of Agricultural Producers".

The mechanism and direction of state support for agricultural producers through the allocation of budget subsidies per unit of cultivated land was approved by the Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Procedure for Using Funds Provided in the State Budget for State Support to Agricultural Producers through the Allocation of Budget Subsidies per Unit of Cultivated Land" (Resolution of the Cabinet of Ministers of Ukraine No. 886, 2021). Under programme 2801580 "Financial support for agricultural producers", subsidies per hectare of buckwheat crops were provided from 2021 to ensure stable production based on domestic demand (Budget subsidies for sowing..., n.d.).

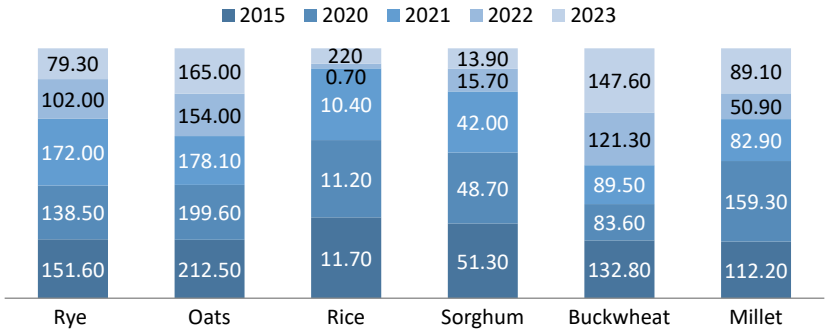

Figure 1. Sown areas of niche grain crops in Ukraine, thousand hectares

Source: compiled by the authors based on Areas, gross harvests and yields of agricultural crops... (2021; 2022; 2023; 2024), Harvesting of agricultural crops...(2016)

The level of development of niche grain production is assessed primarily by the dynamics of harvested areas, gross harvest volumes, and yields. In 2023, compared to 2015, there was a significant decrease in the area under niche crops harvested, except for buckwheat. The area under buckwheat increased by 15.8% in 2023, and its increase was due to the introduction of state subsidies from 2021 per 1 ha of crops (Table 1).

Table 1. Dynamics of harvested areas, gross yields and yields of niche crops in Ukraine

4,272.7	Year					2023 to 2015, %
	2015	2020	2021	2022	2023	
Total area harvested, thousand hectares						
Rye	150.8	137.8	171.6	101.5	78.4	52.0
Oats	210.5	199.0	178.0	153.5	164.8	78.3
Rice	11.7	11.2	10.1	0.7	2.2	18.8
Sorghum	50.6	47.2	41.7	15.2	12.9	26.0
Buckwheat	127.7	84.1	91.9	121.0	147.9	115.8
Millet	112.8	159.1	87.1	49.1	87.9	77.9
Gross harvest, thousand tonnes						
Rye	3,910.7	4,567.8	5,931.5	3,140.3	2,311.8	59.1
Oats	4,885.1	5,100.0	4,679.0	3,785.1	4,272.7	87.5
Rice	625.1	606.8	494.8	30.9	110.8	17.7
Sorghum	1,882.8	1,065.6	1,731.6	403.1	423.7	22.5
Buckwheat	1,281.0	976.4	1,057.8	1,476.9	2,107.2	164.5
Millet	2,132.6	2,560.5	2,049.9	905.8	2,035.2	95.4

Table 1, Continued

Crop	Year					2023 to 2015, %
	2015	2020	2021	2022	2023	
Yield per hectare of harvested area, hwt						
Rye	26.0	37.2	38.1	34.2	30.9	118.8
Oats	22.7	28.0	27.2	24.9	28.1	123.8
Rice	53.4	54.0	49.3	41.7	49.9	93.4
Sorghum	42.4	23.6	46.6	28.3	35.3	83.3
Buckwheat	9.9	11.4	9.9	12.0	14.4	145.5
Millet	19.8	16.4	23.2	19.2	20.1	101.5

Source: compiled by the authors based on Harvesting of agricultural crops... (2016), Areas, gross harvests and yields of agricultural crops... (2021; 2022; 2023; 2024)

The war in Ukraine can also be attributed to the decline in the gross harvest of niche crops. In 2022, compared to 2021, there was a 47% decrease in the gross harvest of rye, a 19.1% decrease in oats, a 93.8% decrease in rice, a 76.7% decrease in sorghum, and a 55.8% decrease in millet. The gross harvest of buckwheat in 2022 increased by 39.6% compared to 2021 due to the introduction of state support for this crop (Table 1). In 2023, compared to 2015, yields of rice decreased by 6.6% and sorghum by 16.7%, while yields of rye increased by 18.8%, oats by 23.8%, buckwheat by 45.5%, and millet by 1.5%, mainly due to weather conditions.

Climatic conditions have a significant impact on the yield of niche cereals, as they determine the quality of the grain, the length of the growing season, and the level of risks associated with droughts, frosts, or excessive moisture. O.V. Vasylenko *et al.* (2024) noted that rye requires moderate rainfall (400-600 mm per season), and in 2022 and 2023 the amount of rainfall in the spring was excessive compared to the long-term norm in Ukraine, the yield of this crop during these years decreased compared to 2021. Sorghum and millet yield also decreased due to drought tolerance, while buckwheat yields increased due to favourable weather conditions in 2022-2023.

Oats were the most consumed niche grain product in Ukraine. In the 2021/22 marketing year, the domestic consumption of oats in the country was 465 thousand tonnes. In the next 24 months, the consumption of this crop decreased by 9.7%, and a significant decline was recorded in the 2022/23 marketing year. Rye was the second most consumed crop, with domestic consumption of 365 thousand tonnes in the 2021/22 marketing year and down 3.6% in the 2023/24 marketing year. Millet ranked third in terms of domestic consumption, but in 2022/23 it decreased by 58% due to the occupation of the territories specialised in growing this crop. Buckwheat consumption in Ukraine remained stable, ranging from 110-150 thousand tonnes per year. The demand for healthy food and gluten-free products has stimulated the cultivation of sorghum, which is used to produce functional and dietary products. However, this crop has not yet become widespread, and its domestic consumption was 70 thousand tonnes in the 2021/22 marketing year and decreased by 85.7% in the 2023/24 marketing year (Table 2).

Table 2. Domestic consumption of niche grain crops in Ukraine, thousand tonnes

Production	Marketing year			2023/24 before 2021/22, %
	2021/22	2022/23	2023/24	
Rye	365	277	352	96.4
Oats	465	405	420	90.3
Rice	115	79	88	76.5
Sorghum	70	10	10	14.3
Buckwheat	110	145	145	131.8
Millet	214	90	215	100.5

Source: compiled based on the research department Domestic consumption of grains in Ukraine... (n.d.)

The production of niche crops such as rye, buckwheat, millet and oats is important to ensure a stable supply of quality food for the population. In the face of climate change and economic challenges, these crops could become key to maintaining national food security. Starting in 2022, the licensing of rye, millet and buckwheat exports was introduced to protect the domestic market and ensure stable supplies. In the context of war, economic instability and disrupted logistics chains, preserving strategic grain stocks can avoid shortages and price spikes for socially important products (Resolution of the Cabinet of Ministers of Ukraine No. 1424, 2021).

By calculating the total food need for the production of niche cereals based on the consumption norms approved at the state level for the main social and demographic groups of the population (Resolution of the Cabinet of Ministers of Ukraine No. 780, 2016), the population as of 1 February 2022 according to the State Statistics Service of Ukraine (Population by region..., 2022) and cereal yields after grain processing (Table 3), it was concluded that there is an insufficient food need for Ukrainian rye bread and rice, despite the ban on rye exports.

In particular, the normative demand for rye bread in Ukraine is met by only 20.3%, and for rice groats by 12.4% (Table 3). The production of other niche grain crops fully met the food needs of Ukrainians in 2023, namely the normative food demand for oat groats was met by 837.6%, buckwheat by 132.6%, and millet by 121.9%. Rice consumption in Ukraine exceeded its production, confirming the need for import to meet domestic demand. Rice imports in 2023 contributed to nearly full coverage of food needs, as demonstrated in Table 4.

Table 3. Calculation of the volume of gross harvest of niche grain crops to meet the food needs of the population of Ukraine

Crop	Consumption rates		Cereal (flour) yields, %	Total food demand (estimated), thousand tonnes	Coverage of the normative food requirement in 2023, %
	per 1 person, kg/year	total, tonnes per year			
Rye	21.3	877.6	70.0	1,140.9	20.3
Oats	0.8	32.9	45.5	51.0	837.6
Rice	1.6	65.9	65.0	89.0	12.4
Buckwheat	2.9	119.5	67.0	158.9	132.6
Millet	3	123.6	65.0	166.9	121.9

Source: compiled by the author based on Grain technology (n.d.), Resolution of the Cabinet of Ministers of Ukraine No. 780 (2016) and Population by Region... (2022)

Table 4. Imports of niche grain crops to Ukraine, tonnes

Production	2015		2020		2021		2022		2023	
	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%
Rye	28	0.03	1,859	1.04	1,331	1.02	116	0.11	90	0.12
Oats	0	0.00	761	0.42	410	0.31	12	0.01	5	0.01
Rice	84,656	81.18	112,161	62.45	81,780	62.78	86,894	82.39	76,548	98.76
Sorghum	7,627	7.31	193	0.11	382	0.29	314	0.29	32	0.04
Buckwheat	6,022	5.77	32,397	18.04	24,579	18.87	9,152	8.68	502	0.65
Millet	5,953	5.71	32,226	17.94	21,773	16.72	8,982	8.52	331	0.43
Total	104,286	100	179,597	100	130,255	100	105,470	100	77,508	100

Source: compiled based on Commodity structure of foreign trade... (2016; 2021; 2022; 2023; 2024)

Table 4 shows that in 2015, 2020-2023, rice occupied the largest share in the structure of imports of niche grains, namely 81.18% in 2015, 82.39% in 2022, and 98.76% in 2023. This is due to the limited climatic conditions for growing it in Ukraine, high costs of irrigation, equipment, energy, stable domestic demand and cheap imports. The 17.6% increase in rice imports in 2023

compared to 2015 is due to a decline in rice production in Ukraine due to the occupation of the southern regions, which were its main producers.

Low imports of all other niche crops can be explained by sufficient domestic production and insignificant demand for these products on the domestic market. Even though most of the products of niche cereals are consumed on the domestic market, their production may be promising for international trade. Buckwheat, oats, sorghum, and rye are in demand in the EU, Asia, and North America, which opens up opportunities for expanding Ukrainian exports.

An analysis of statistical information on the production and export of niche cereals in Ukraine determined that export sales are insignificant compared to production (Fig. 2). The largest exports were of sorghum compared to production. This figure was highest in 2022 at 176.8%, and lowest in 2021 at 34.6%. The surplus of exports over production of sorghum is determined by the use of previous years' stocks, re-exports, and difficulties in registering the harvest during the war, as regions with favourable soil and climatic conditions for growing this crop are concentrated in the South of Ukraine. Millet was the second largest export crop. This figure was the highest in 2021 at 81.7%, and the lowest in 2015 and 2023 (27.2% and 33.9%, respectively). In 2021, an increase in the gross harvest of rye to 593.1 thousand tonnes was noted, which exceeded domestic needs. Due to high rye yields, limited domestic consumption and increased external demand caused by low yields in Europe, rye exports in 2021 amounted to 23.0%, the highest in the study period. Other crops accounted for a small share of exports, however, Figure 2 shows a significant export potential for niche cereals such as oats, buckwheat and millet.

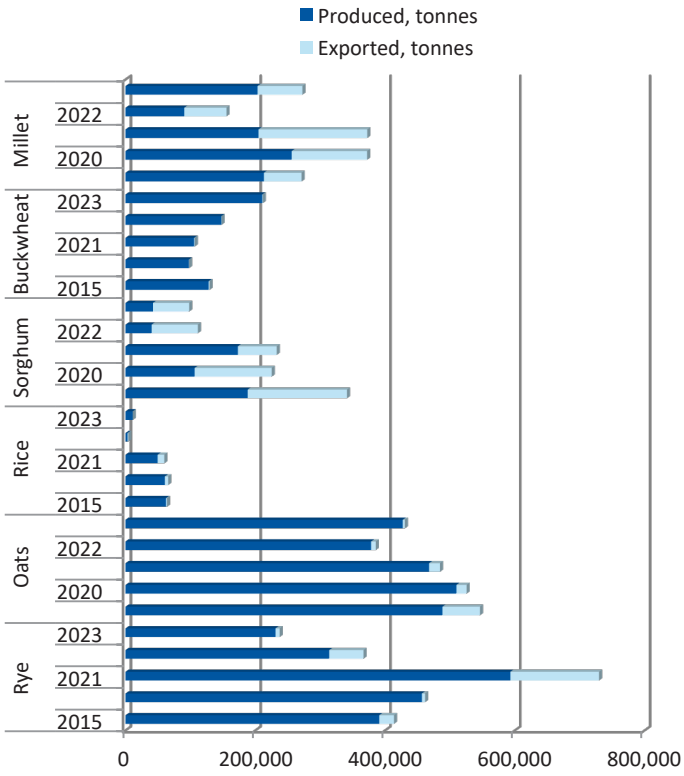

Figure 2. Production and export of niche grain crops to Ukraine, tonnes

Source: compiled based on Commodity structure of foreign trade... (2016; 2021; 2022; 2023; 2024), Areas, gross harvests and yields of agricultural crops... (2021; 2022; 2023; 2024), Harvesting of agricultural crops... (2016)

One of the issues for farmers growing niche crops is the marketing efficiency. As the market for these products is limited, farmers may face difficulties in establishing stable sales. In contrast to other agricultural products with well-developed logistics infrastructure and demand, niche crops require a special approach. Furthermore, a larger supply may cause additional price reductions due to increased competition. This involves finding new markets, improvement of consumer awareness, and establishment of cooperation with distributors and processing companies.

Among the factors causing difficulties in the sale of niche grain crops, the following is notable: small acreage compared to major export grains such as wheat, corn and barley; priority on domestic consumption, which prevents the formation of large export consignments; unstable global demand for niche grains; the need for separate logistics infrastructure due to the small consignments of niche grain crops, potentially economically damaging; the requirement to comply with the certification standards of importing countries to enter international markets; the lack of state support programmes for the production of niche grain crops.

To improve production and sales of niche crops, it is necessary to develop an economic mechanism that contributes to the industry. Justification of the economic feasibility of niche crops requires a comprehensive assessment of the production efficiency and sales, as this can be fully assessed only after the sale of products. Determination of economic efficiency should include not only the costs but also an analysis of market conditions, supply and demand, pricing, logistics costs and profitability. Only an integrated approach can be used to form an objective view of the economic feasibility of niche crops and ways to optimise production and commerce.

The economic mechanism for the production and sale of niche grain crops, which is shown in Figure 3, ensures a balanced combination of elements that will increase the efficiency of production and sales of niche crops, ensure competitiveness and improve sales.

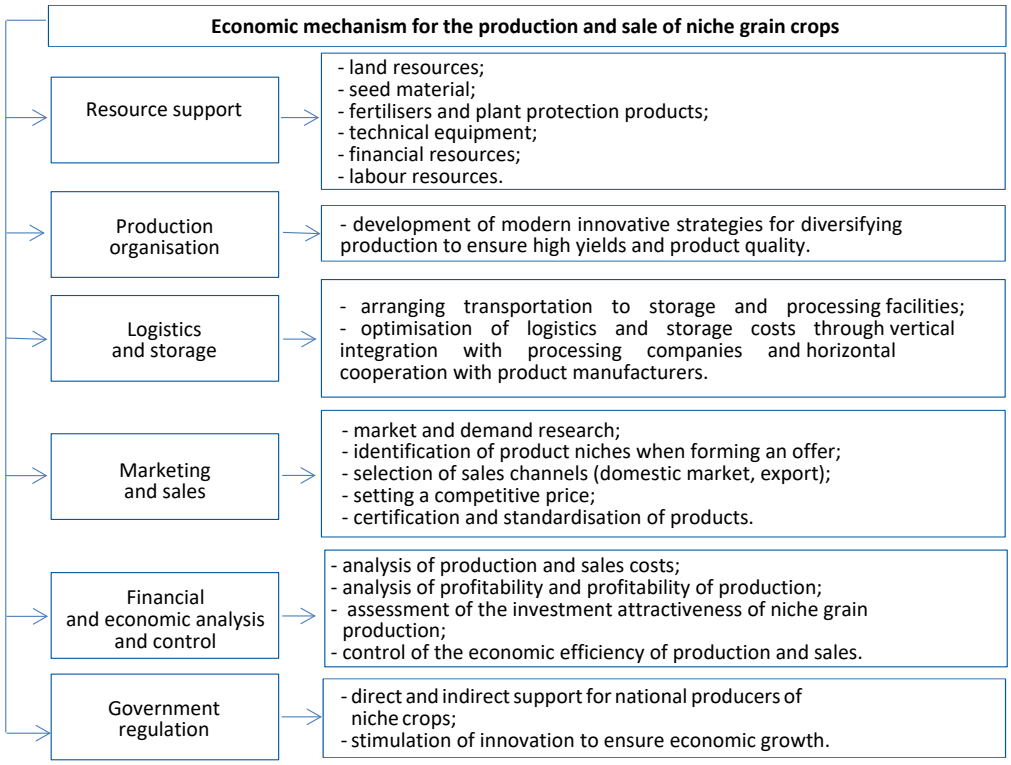

Figure 3. Economic mechanism for the production and sale of niche grain crops
Source: compiled by the authors based on O. Fedirets (2021), T. Demianenko (2024)

Modern innovative strategies for diversifying the production of niche cereals, which are part of the Production Organisation component (Fig. 3), should include the introduction of advanced agricultural technologies, the use of varieties resistant to climate change, optimisation of production processes, digitalisation of agribusiness and the application of environmentally sound management practices. Such strategies should be aimed at increasing the efficiency of production and land use, expanding market opportunities and strengthening the competitiveness of the agricultural sector. Improving the structure of cultivated areas using small plots of land (land shares, plots unsuitable for large-scale production) will enable economic entities to make the most effective use of available land resources, while expanding crop areas through niche grain crops will contribute to the diversification of agricultural production through more efficient use of crop rotation, technology and labour resources.

Greening of agricultural production involves the introduction of environmentally friendly technologies, reducing the anthropogenic impact on the environment and increasing the resilience of agroecosystems. The cultivation of niche crops such as rye, oats, buckwheat, millet, sorghum and rice will contribute to this process due to their unique agronomic and environmental characteristics. Rye and buckwheat actively improve soil structure, preventing soil erosion, while sorghum and millet are highly drought-resistant, reducing the need for water resources. Oats are known for their ability to improve soil biological activity and serve as a natural phytosanitary element in crop rotations.

Based on the study, it is possible to conclude that the economic mechanism for the production and sale of niche cereals is a system of interrelated components, including resource provision, organisation of production processes, logistics and warehousing operations, marketing strategy, financial and economic analysis, performance monitoring and government regulation. Its main goal is to ensure the rational management of production, sales and market development of niche cereals, contributing to their competitiveness and sustainability in the market.

The unique capabilities of niche cereals identified in the study are confirmed by the American scientist J. Klein (2022), who noted that oats have the potential to clean groundwater due to the high absorption capacity of its root system, which can absorb and retain nitrates. S.M. Kalenska & N.V. Novytska (2024) noted that the cultivation of niche cereals reduces the use of chemical fertilisers and pesticides, as many of them have natural resistance to pests and diseases, namely Sorghum, thanks to the high content of tannins in the grain and a waxy coating on the leaves, has natural resistance to many pests and fungal diseases. Buckwheat contains natural phytoncides that inhibit the development of diseases and repel some pests, including aphids millet, thanks to its dense grain shell and undemanding growing conditions, is less susceptible to fungal diseases and pests rye has high natural resistance to many diseases, including smut fungi and root rot, and is less susceptible to pests than wheat; oats are relatively resistant to diseases, especially rust and root rot, and contain anti-nutritional substances that reduce their attractiveness to pests.

An important aspect of a modern business environment is the reduction of the carbon footprint of agricultural production by reducing energy consumption for soil cultivation and reducing greenhouse gas emissions. The use of niche crops in mixed agroecosystems and organic farming will help create balanced ecological chains that support the natural processes of regulating soil fertility and biological balance. In the process of greening agricultural production, the state is central by providing the legal, economic and organisational framework for the introduction of environmentally friendly technologies. In particular, the provision of government subsidies and preferential loans to producers using organic technologies, as well as tax incentives for enterprises implementing environmentally friendly farming methods, will help ensure the greening of niche grain production.

This statement is also supported by M. Ilchuk *et al.* (2023a), concluding that to slow down soil degradation caused by the loss of organic carbon and to improve the agro-ecological situation in Ukraine, it is necessary to introduce a system of economic incentives for measures aimed at restoring soil fertility. To do this, an environmental tax should be introduced for agricultural producers in case of violation of the

scientifically based structure of sown areas, which will help preserve the natural balance of soil resources and ensure sustainable development of the agricultural sector.

The proposals of the authors of the study on the need to develop an economic mechanism for the production and sale of niche grain crops, which will contribute to the development of the industry, coincide with the views of other researchers. T. Demianenko (2024) noted that the economic mechanism serves as the foundation for ensuring the effective functioning of economic systems at all levels, from the individual enterprise to the national economy, and is the main tool for stimulating economic growth. O. Fedirets (2021) defined the organisational and economic mechanism of enterprise development as a set of interrelated methods, tools means and regulatory levers that ensure effective management of organisational and economic processes. Its main task is to contribute to the achievement of the strategic goals of the enterprise, adapt to changes in the internal and external environment, as well as to increase the competitiveness and sustainability of the enterprise in a dynamic market.

The results of the study on the feasibility of selling niche crops on the domestic market, developing the processing and creating cooperatives of niche producers, also confirmed the findings of other scientists. L.O. Boiko (2024) noted that to minimise the risks of growing and selling niche crops, farmers need to incorporate not only the agronomic features of their production but also develop effective market integration strategies. This may include diversifying sales channels, establishing cooperatives to enter the market together, entering long-term contracts with buyers, and developing their processing facilities to produce value-added products. Only a comprehensive approach that combines modern agricultural technologies with business strategies will enable producers to successfully integrate niche crops into their agribusinesses and ensure their competitiveness both in the domestic and foreign markets.

Other researchers also concluded that niche crops are highly profitable. L. Boiko (2023) concluded that an important argument for diversifying agribusiness by introducing certain crops into crop rotation is that most of them have a higher market price than conventional crops. The price of buckwheat can be as high as 20 thousand UAH/t, and its profitability in 2020 was 54.7%, and in previous years it was 100%. O. Titarenko (2022), having conducted an economic assessment of the efficiency of grain sorghum cultivation, concluded that, according to the technology of growing this crop, the costs per unit area ranged from 21,322 to 22,697 UAH, excluding land rent and other additional payments, and the cost of sales of the products produced ranged from 53,227 to 70,921 UAH/ha, which indicates the economic feasibility of growing grain sorghum under modern economic conditions. S. Kalenska & V. Naidenko (2019) determined that a profit of 28.9 and 25.4 thousand UAH/ha can be obtained by growing grain sorghum hybrids Brigga F1 and Burggo F1, respectively. S. Volodin (2021) noted the significant potential of oats in diversifying Ukrainian agricultural exports and increasing the profitability of the grain industry, which the author attributes to global trends in healthy lifestyles and organic farming.

The statement that some cereals are characterised by high drought tolerance, which can be used to be successfully grown in regions with unstable climatic conditions, correlates with the findings of M. Van Zonneveld *et al.* (2023) on analysis of niche crops in the context of climate change in sub-Saharan Africa (SSA). The study believed that these crops can open up significant opportunities for diversifying agricultural production, which is an important strategic step towards overcoming hunger and ensuring a balanced diet. The proposal for green agricultural production through the introduction of niche cereals is in line with the opinion of A. Burliai *et al.* (2021), argue that the greening of agriculture is an essential condition for the sustainable development of society and is recognised as one of the key concepts of the present era.

The study significantly contributed to the expansion of the scientific and theoretical basis for organising the production and sale of niche crops, by substantiating the strategic directions of development of this segment of the agricultural sector. The proposed economic mechanism for the production and sale of niche

grain crops is a tool for improving the efficiency of agricultural production, strengthening the competitiveness of Ukrainian producers and ensuring sustainable development of the industry in the context of market transformations and changes in the external environment.

CONCLUSIONS

The study demonstrated that in 2023, compared to 2015, the harvested area of niche crops decreased significantly, except buckwheat, which increased by 15.8% due to government subsidies introduced in 2021. The decrease in the area in 2022 was mainly caused by the military actions in Ukraine. The area under rice decreased by 93.8%, sorghum by 76.7%, millet by 55.8%, rye by 47% and oats by 19.1%. In the 2021/22 marketing year, oats were consumed in Ukraine the most – 465 thousand tonnes, but over the next two years, these volumes decreased by 9.7%, with the biggest decline in the 2022/23 marketing year. Rye was the second most consumed grain, amounting to 365 thousand tonnes, but in the 2023/24 marketing year, its consumption decreased by 3.6%. Millet was the third most consumed product, but in the 2022/23 marketing year, its volume decreased by 58% due to the occupation of the producing territories. Buckwheat consumption was stable at 110-150 thousand tonnes per year. The demand for gluten-free products stimulated sorghum cultivation, but due to the low popularity of this product, its consumption decreased by 85.7% from 70 thousand tonnes in the 2021/22 marketing year to 10 thousand tonnes in the 2023/24 marketing year.

Based on the calculation of the total food demand for niche grain production, it was concluded that the normative food demand for rye bread (20.3%) and rice (12%) produced in Ukraine is insufficiently met. Rice consumption in Ukraine has consistently exceeded domestic production, which necessitates imports to cover domestic needs. In 2023, imports of rice almost fully covered the food needs of the population, and this crop traditionally occupied the largest share in the structure of niche grain imports: 81.18% in 2015, 82.39% in 2022, and 98.76% in 2023. Although most of the niche grains were consumed domestically, crops such as buckwheat, oats, sorghum, and rye have export potential due to demand in the EU, Asia, and North America. The analysis of statistical information shows insignificant exports of niche grains compared to their production, except sorghum, which in 2022 exceeded production by 176.8% due to residues, re-exports and difficulties in registering the harvest. Millet is in second place, with the highest exports recorded in 2021 (81.7%). Significant exports of rye in 2021 (23.0%) were driven by a high harvest, low domestic consumption and demand from the EU. The main challenge for agricultural producers specialising in niche crops is to establish an effective sales system. The results of this study indicated that Ukrainian producers of niche crops should focus primarily on the domestic market, and in case of overproduction, consider export prospects. This conclusion is based on several factors identified in the course of analysing the production and marketing of these products.

The production of niche crops is an important component of food security, especially in times of economic instability. It helps to avoid shortages and price fluctuations, reduce import dependence and provide the food industry with quality raw materials. The effective functioning of the economic mechanism in this area involves the development of domestic processing, which creates added value, and new jobs and supports domestic producers. Niche cereals, such as sorghum and millet, are suitable for growing in the face of climate change and lack of precipitation due to their drought tolerance, which makes them economically viable in the face of a shortage of traditional products. Expanding the cultivation of rice and rye, which are partially imported to Ukraine, will help stabilise prices and avoid shortages. The introduction of such crops contributes to the greening of agricultural production, the rational use of land resources and the production of environmentally friendly products with high added value.

To improve the efficiency of production and sales of niche grain crops, an economic mechanism was developed to promote the development of the industry. It includes a balanced combination of its interrelated components, namely resource provision, organisation of production processes, logistics and warehousing operations, marketing strategy, financial and

economic analysis, performance monitoring and state regulation. Its main objective is to ensure rational management of production, sales and market development of niche grains, thereby contributing to the competitiveness and sustainability in the market. Prospects for further research include a comprehensive analysis of the economic efficiency of production and sales of niche crops, including the impact of organisational and economic factors on profitability, logistics and marketing aspects of sales, the level of competitiveness in different markets, and the development of state support mechanisms, incorporating economic transformations and climate change.

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CONFLICT OF INTEREST

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Микола Ільчук
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0001-5129-6110
Людмила Березовська
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-2782-032X

Організаційно-економічні аспекти виробництва та продажу зерна нішевих культур

Анотація. Попри значні переваги виробництва продукції нішевих зернових культур, товаровиробники часто зіштовхуються з низкою проблем, таких як дисбаланс попиту й пропозиції, висока ресурсоємність і значна частка нематеріальних витрат, що ускладнює масштабне впровадження та потребує глибокого наукового аналізу для пошуку ефективних рішень. Метою статті була розробка та обґрунтування економічного механізму виробництва та продажу продукції нішевих зернових культур. У процесі дослідження застосовувалися такі наукові методи: збір та аналіз даних, бібліографічний метод, метод економічного аналізу, моделювання та логічного узагальнення. В дослідженні проведено всебічну оцінку сучасного стану виробництва та продажу продукції нішевих зернових в Україні, а саме: гречки, жита, вівса, проса, сорго та рису. Аналіз включав оцінку площ, валових зборів, урожайності, внутрішнього споживання, імпорту та експорту продукції. Дослідження показало значне зменшення площ під нішевими зерновими культурами у 2022 р. спричинене військовими діями на території України. Площі під рисом скоротились на 93,8 %, під сорго – на 76,7 %, під просом – на 55,8 %, під житом – на 47 % та під вівсом – на 19,1 %. В статті проведено розрахунок загальної нормативної продовольчої потреби у виробництві продукції нішевих зернових та зроблено висновок про недостатньо забезпечену продовольчу потребу в житньому хлібі (20,3 %) та рисі (12 %) українського виробництва. Оцінка імпорту продукції нішевих зернових показала, що рис традиційно займав найбільшу частку в структурі імпорту: 81,18 % у 2015 р., 82,39 % у 2022 р. та 98,76 % у 2023 р. На основі дослідження розроблено економічний механізм виробництва та продажу нішевих зернових культур, що включає ресурсне забезпечення, організацію виробництва, логістику, маркетинг, фінансовий аналіз, контроль ефективності та державне регулювання. Результати дослідження мають практичну цінність для виробників нішевих зернових культур, які прагнуть диверсифікувати діяльність, адаптуватися до ринкових і кліматичних змін та підвищити економічну ефективність виробництва і збуту

Ключові слова: нішеві культури; інноваційні стратегії диверсифікації; експорт; імпорт; маркетинг; логістика

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Volodymyr Nazarenko*
PhD, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-7433-2484

Andrii Martyn
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-6905-2445

Urban growth and agrarian dynamics: Evaluating the Kyiv agglomeration's economic landscape

Abstract. This study investigated the effects of rapid urban expansion on agricultural economic dynamics within the Kyiv agglomeration. The research analysed changes in land use, wage levels, enterprise output, and logistics infrastructure using a comprehensive dataset compiled from national land cadastre records, economic reports, and regional statistics prior to 2023. The results revealed significant pressure on agricultural territories: only 0.21% (0.18 thousand hectares) of land within the region was designated for agricultural use, compared to over 54% assigned to green zones and nearly 13% to residential categories. Concurrently, average monthly salaries in Kyiv's food-processing industry reached 16,500 UAH, while agricultural wages in surrounding areas lagged at 14,000 UAH, influencing labour migration from rural to urban sectors. Moreover, transport costs – ranging from 20 to 250 UAH per kilometre depending on location and vehicle type – further impacted enterprise viability and spatial decision-making. A notable discrepancy in land rental rates was also evident: land within the Kyiv metropolitan core commanded rents of up to 25 million UAH per hectare per year, compared to an average of 3,474 UAH in the region. These factors contributed to the encroachment of farmland for residential, commercial, and industrial use. The study concluded that effective urban-rural land-use governance – through zoning regulations, fiscal incentives, and sustainable planning – was essential to safeguard agricultural viability and ensure balanced regional development amid Kyiv's ongoing metropolitan growth. Findings from this research could inform strategic land-use planning, guide interventions to mitigate adverse impacts on agriculture and foster a more balanced urban-rural dynamic in rapidly evolving metropolitan regions

Keywords: urban expansion; agricultural economy; land-use change; metropolitan growth; socio-economic development; resource economics

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*Corresponding author

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INTRODUCTION

Rapid urbanisation and the consequent spatial expansion of city boundaries increasingly influence agricultural land use and economic structures worldwide. As metropolitan areas grow in population and infrastructure, conflicts often arise between residential-industrial development and the preservation of agricultural resources. These conflicts are particularly evident in rapidly expanding urban centres, where diverse economic sectors converge and compete for limited land resources. In this context, the Kyiv agglomeration – encompassing the city of Kyiv and its surrounding territories – is a pertinent case study to analyse the consequences of such expansion on regional agriculture and allied industries.

The rapid intensification of urban development in metropolitan regions has emerged as a significant factor in reshaping land use and economic structures, particularly in agricultural systems. The competition for land between expanding residential, industrial, and infrastructural developments and traditional farming areas is becoming increasingly acute. This challenge is especially critical in regions undergoing swift spatial transformations, such as the Kyiv agglomeration (State Land Cadastre of Ukraine, n.d.). As Ukraine's administrative and economic core, Kyiv exerts substantial influence over surrounding territories, prompting substantial reallocation of land resources and labour flows (State Statistics Service of Ukraine, n.d.). These dynamics necessitate a comprehensive understanding of the consequences of urban expansion and its impact on agriculture, food security, and sustainable development (Open Data Portal of Ukraine, n.d.). Examining this intersection is essential for devising balanced territorial development strategies that align economic growth with ecological and socio-economic stability.

Academic contributions have explored the complex relationship between urbanisation and agricultural sustainability from various regional and disciplinary perspectives. For instance, the study by N. Vasylieva & H. James (2021) highlighted the dual nature of urban expansion, demonstrating that while it introduces infrastructural improvements and market access, it simultaneously disrupts traditional agricultural zones and undermines the food security of peri-urban populations. V. Beckers *et al.* (2020) analysed land-use conflicts in Belgium, showing that agricultural productivity decreases significantly in areas subject to rapid urban encroachment due to fragmented landholdings and logistical inefficiencies.

Within the European context, W. Oueslati *et al.* (2019) evaluated the impact of urban growth on agricultural productivity across several metropolitan regions. The findings emphasised that regulatory policy gaps and uncontrolled real estate development accelerate the decline of cultivated areas and reduce ecological resilience. In a different regional setting, S.K. Patel *et al.* (2019) studied land-use changes in peri-urban India and concluded that shifts in land cover correlated directly with socio-economic transformations, labour redistribution, and altered investment patterns in agricultural enterprises.

Studies focusing on the Global South further reinforce the significance of this issue. A. Follmann *et al.* (2021) systematically reviewed how farmers in rapidly urbanizing areas of Latin America, Africa, and Asia adapt or withdraw from agriculture, depending on state support and infrastructural accessibility. Similarly, I. Duvernoy *et al.* (2018) explored the French city of Toulouse, where urban development at the city's fringe resulted in fragmented agricultural landscapes, land speculation, and a weakening of local agri-food systems. In the Ukrainian context, O. Kravchenko *et al.* (2020) examined socio-economic transformations affecting agriculture and underscored the importance of sustainable land-use practices amid ongoing demographic shifts and regional development challenges. The findings support the notion that strategic governance and modernisation of rural infrastructure are vital for maintaining the viability of agriculture in regions facing intense urbanisation, such as the Kyiv agglomeration.

Ukrainian scholars have also contributed to this field, offering region-specific insights. V. Nazarenko (2020) examined the economic implications of land-use transformation in the Kyiv metropolitan area, revealing the pressure

on agricultural enterprises caused by increasing rent values, shifting labour availability, and spatial dislocation. In a related study, V. Nazarenko (2021) analysed how food-processing enterprises in and around Kyiv adjust the production strategies in response to urbanisation, highlighting the role of spatial proximity to markets, transportation networks, and resource availability.

These scholarly works underscore that urbanisation – if not strategically managed – poses significant risks to agricultural sustainability, regional food systems, and balanced territorial development. The works also affirm the necessity of adopting adaptive, context-specific policy measures and land-use frameworks that recognise agricultural landscapes' economic, ecological, and social value, particularly in expanding metropolitan areas. The purpose of this study was to assess the spatial and economic effects of urban expansion on the agricultural sector within the Kyiv agglomeration by analysing empirical data on land use, enterprise activity, wage structures, and infrastructure to identify patterns and policy gaps that affect the viability of agriculture in metropolitan territories.

MATERIALS AND METHODS

The methodological framework of this study was designed to comprehensively assess the economic and spatial transformations in the Kyiv agglomeration under the influence of urban growth, with a focus on the agricultural sector. A combination of qualitative and quantitative research methods was employed to achieve this. Legal and regulatory documents, including the Land Code of Ukraine (2001), Law of Ukraine No. 858-IV (2003), Law of Ukraine No. 3038-VI (2011), were referenced to contextualise land-use policies and zoning frameworks.

The primary method used was statistical analysis, which enabled the evaluation of socio-economic indicators such as land use distribution, wage structures, number of enterprises, production output, and transportation costs. Descriptive statistics (State Statistics Service of Ukraine, n.d.) were used to calculate collected data percentages, averages, and ratios. These methods were essential to identifying trends in land conversion, shifts in economic activities, and regional development disparities.

The empirical data used in the study covered the period from 2000 to 2022 as the main research data, whereas for comparison, the data from 1995 and 2019 were used in the study (due to the importance of those periods to observe changes in the dynamics). Particular emphasis was placed on the post-2010 phase, during which the most significant shifts in land use and urban expansion were observed. This timeframe enabled the analysis of long-term trends in metropolitan development and the cumulative effects on agricultural economic indicators. The geographical focus of the research was the Kyiv agglomeration, which included the administrative territory of Kyiv city and the adjacent Kyiv region (oblast). The area encompassed the dense urban core and surrounding suburban and rural zones within a 50-kilometre radius of the capital. This territory was selected due to its strategic economic role, high population density, and pronounced land-use dynamics, making it an ideal case for studying the intersection of urbanisation and agricultural transformation.

The correlational analysis examined the relationships between urban development indicators (e.g., residential and industrial land area) and agricultural variables (e.g., land rent, enterprise revenue, employment). This approach helped determine how increased urban land occupation corresponded with decreases in agricultural land availability and rising land rental costs (Fig. 1). The cartographic method spatially visualised changes in land use, infrastructure distribution, and the geographical positioning of agricultural and food-processing enterprises. Particular attention was paid to distinguishing urban areas from adjacent territories, allowing for a comparative perspective on land occupation and socio-economic indicators in Kyiv versus peripheral locations (Table 1).

The comparative method was also applied to contrast urban and peri-urban zones regarding land price, rent, labour wages, and enterprise output. The factual material for this study was drawn from multiple official and publicly accessible sources (Kyiv Statistics Service, n.d.; State Statistics Service of Ukraine, n.d.).

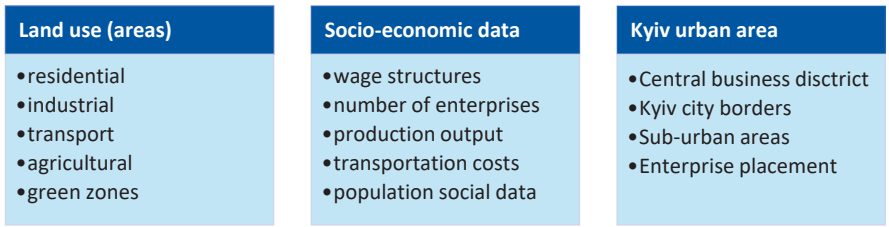

Figure 1. Article research data grouped by categories
Source: developed by the authors

Table 1. Research socio-economic indicators

Key socio-economic Indicators	Description
Land use structure	Percentage and total area (in thousand hectares) allocated to residential, industrial, transport, green, and agricultural zones.
Wage levels	Average monthly and annual wages across sectors (agriculture, food processing, construction, mining, etc.) in Kyiv and the surrounding region.
Enterprise distribution and output	Number of agricultural and food-processing enterprises, average number of employees, and average annual production output per enterprise.
Land market indicators	Average land sale price and rental rate per hectare in Kyiv vs. Kyiv region; total land area available for sale/lease.
Population demographics	Urban vs. rural population proportions, total population in the city and surrounding region, labour force distribution.
Transport and logistics costs	Average transportation costs per kilometre by vehicle type and product category (e.g., grain, milk, poultry).
Consumer spending	Average per capita food expenditure, including specific categories: meat, milk, bread.
Sectoral contribution to GDP	Share of agriculture and food processing in national GDP, export focus of large enterprises, and income distribution across enterprise sizes.
Housing and infrastructure indicators	Cost of rent and housing stock per capita, spatial expansion patterns of urban development.

Source: developed by the authors

Data cleaning and validation involved cross-referencing multiple official registries and published studies to minimise inconsistencies and measurement errors. Descriptive statistics were used to depict key parameters such as the percentage of land allocated to different categories and the corresponding total area in thousand hectares. Correlational analysis was subsequently performed to identify relationships between urban expansion indicators (e.g., increase in residential or industrial land) and agricultural performance measures (e.g., land availability, enterprise revenues, and wage levels). Where relevant, data were standardised for currency fluctuations and varying measurement scales, ensuring comparability across different sources. The resulting integrated approach facilitated a robust examination of how metropolitan growth processes intersected with and reshaped the agricultural economy in the Kyiv agglomeration.

RESULTS AND DISCUSSION

Over the 20th century, the Kyiv metropolitan area has transformed from a relatively compact urban centre into a far-reaching agglomeration encompassing the capital of Ukraine and a constellation of surrounding towns and rural settlements. In the early 1900s, urban development was primarily concentrated within the city's historical core, and agricultural lands on the outskirts occupied approximately 70-75% of the broader region. However, socio-economic transformations – including industrialisation, infrastructure upgrades, and targeted development policies – catalysed steady population

growth and progressively integrated peripheral areas into the urban domain. For instance, between 1926 and 1989, Kyiv's population surged from around 513,000 to 2.57 million, reflecting the region's growing economic significance and drawing substantial in-migration (State Statistics Service of Ukraine, n.d.).

The Soviet-era (1922 to 1991) placed emphasis on centralised industrial growth, was pivotal in this expansion. Large production complexes and housing developments were systematically sited on former farmland, particularly in the 20-30 km zone outside the city centre. According to archival land-use records, by the 1980s, more than 25% of the agricultural land within that radius had been converted for industrial or residential use (State Land Cadastre of Ukraine, n.d.). Market liberalisation and private investments accelerated this trend in the post-Soviet period 1991 – present. From 2000 to 2020, official statistics indicate that an additional 14-16% of farmland near Kyiv was repurposed for commercial and residential construction (State Statistics Service of Ukraine, n.d.). As of 2022, the Kyiv agglomeration spanned roughly 2,600 square kilometres, housing over 4.7 million people – underscoring the area's ongoing expansionary pressures (Kyiv Statistics Service, n.d.).

This continuing encroachment upon agricultural territories illustrates one of the most pressing issues facing the contemporary Kyiv agglomeration: balancing rapid urbanisation with farmland's ecological and socio-economic value. Studies estimate that, compared to the 1960s, arable land in the region has diminished by approximately 35%, contributing to structural changes in local employment, disruptions in traditional food supply chains, and potential declines in soil fertility (Nazarenko, 2020; Kravchenko *et al.*, 2020). While the shift toward housing, commercial centres, and logistics hubs has helped modernise the regional economy, these developments also highlight the risks of overextending urban sprawl at the expense of strategic agricultural assets (Duvernoy *et al.*, 2018; Follmann *et al.*, 2021). The region's long-term resilience will hinge on implementing robust land-use governance, sustainable planning directives, and concerted efforts to reconcile future urban growth with the imperative to conserve vital farmland resources.

To better understand the specific dynamics of land transformation and agricultural displacement in the Kyiv agglomeration, this study conducted a detailed empirical assessment using spatial, economic, and demographic data collected from official statistical sources and open-access platforms. The following results represent the synthesised outcomes of this data-driven investigation, offering insights into how urbanisation has materially reshaped the agricultural landscape in and around Kyiv (Table 2).

Table 2. Kyiv region data (2022)

Land use, by category	Land occupied, % of total region	Total land area, thousand hectares
Total	100	82.64
Residential buildings	1.56	12.97
Private buildings	4.75	3.93
Industrial and production areas	7.99	6.61
Transport and infrastructure	7.45	6.16
Green zones	54.48	45.03
Water	7.33	6.06
Agricultural and faring	0.21	0.18

Source: developed by the authors based on Kyiv Statistics Service (n.d.), State Land Cadastre of Ukraine (n.d.)

An initial glance at Table 2 reveals that the Kyiv region's land-use structure is heavily skewed toward green zones, which occupy more than half of the total area (54.48%). By contrast, agricultural and farming land accounts for a mere 0.21%, representing only 0.18 thousand hectares. This notable imbalance suggests that farmland has become increasingly marginal within the regional landscape and may be more susceptible to conversion under ongoing urban

expansion pressures. The relatively modest share of residential buildings (1.56% of total regional land, or 12.97 thousand hectares) compared to industrial and production areas (7.99%) might initially seem to indicate a limited footprint of housing-related development; however, the distinct category of "private buildings" (4.75%) and the significant "other" category (16.3%) indicate potentially diverse and unclassified uses that could include emerging suburban settlements and mixed-use developments. These categories underscore the multifaceted nature of land-use change, with green areas, industrial zones, and private building plots competing for space – a trend likely to intensify as the region's urbanisation accelerates. Table 3 delivers the economic data and offers a deeper look at possible drivers behind these land-use dynamics.

Table 3. Kyiv economic data (2022)

Data category	Kyiv	Kyiv area
Average monthly salary	16,186 UAH mining industry 44,405 UAH construction 8,311 UAH	8,000
Average rent for housing	22,500	13,500
Housing stock of the city	9.1 mln m^2 20.2 m^2 per person	—
Average cost of renting a flat in Kyiv	\$9.4 per m^2 \$263.2 per 28 m^2 of flats	\$3.6
Number of business entities	294,458 companies	7,850
Number of full-time employees	1,149,074 people The average number of employees in one company was 16 people	370,000
Volume of products produced per one (medium-sized) enterprise	36,843.35 thousand UAH per year or 3,070.2 thousand UAH per month	23,500.00 thousand UAH per year
Total land area for sale/lease, hectare	2,812,100	
Land price per hectare	2,694	3,474
Land rent per hectare per year	25,000,000 UAH	—

Note: 1 US dollar = 28.48 UAH (2022), "—" means no data available
Source: calculated by the authors based on State Statistics Service of Ukraine (n.d.)

Within Kyiv, the average monthly salary stands at 16,186 UAH – substantially higher than many other regions of Ukraine – while the mining industry's pay (44,405 UAH) far exceeds the local average (Table 3). This disparity indicates a strong economic pull toward industrial jobs within the metropolitan core. This effect may encourage further commercial and residential development in outlying areas with cheaper land. In addition, the construction sector's average salary (8,311 UAH in Kyiv and 8,000 UAH in the surrounding zone) reinforces the notion that construction activities are robust in the city centre and the adjacent districts. Such a backdrop suggests a vigorous construction market that could drive more rapid conversion of farmland to real estate projects, whether residential, industrial, or commercial.

Another telling indicator is the average rent cost in Kyiv (9.4 USD per m^2), contrasted with only 3.6 USD per m^2 in the surrounding area. This disparity creates substantial incentives for residents and businesses to relocate outside city limits. As the housing market pushes outward, formerly agricultural plots on the outskirts could yield higher profits if converted into residential or mixed-use complexes. Coupled with an abundant total land area available for sale or lease (over 2.8 million hectares in the broader region) and a land price per hectare ranging from 2,694 UAH in Kyiv to 3,474 UAH in the region, it appears there is ample opportunity for real estate development to encroach on farmland.

A key insight emerges when considering that the land rent per hectare per year in Kyiv is cited at 25,000,000 UAH – a figure that may appear

extraordinarily high compared to the per-hectare cost but could reflect prime urban parcels or specific commercial sites. Regardless of the precise breakdown, the strong financial returns from urban and industrial uses of land suggest that agricultural plots remain at risk for conversion if regulatory safeguards are lacking or farmland cannot generate comparable returns.

Collectively, these data hint at several hypotheses. First, the disproportionately low share of agricultural land (just 0.21%) raises questions about the long-term viability of farming in the Kyiv region if expansionary development trends continue unchecked. Second, the interplay between high salaries in specific urban industries and the increasing cost of housing suggests that population and businesses are apt to spill over into less expensive surrounding territories, thereby spurring more significant land-use change in suburban and rural zones. Third, the magnitude of green space (54.48%) might function as a buffer to some extent. However, if market pressures remain strong and strategic land-use policies are weak or poorly enforced, portions of these green zones could eventually face the same conversion pressures as farmland.

These observations reinforce the notion that the region's agricultural sector stands on precarious ground as urbanisation gathers pace. It also underscores the importance of a nuanced, data-driven approach to land management in a rapidly evolving metropolitan environment like Kyiv's, where competing interests increasingly vie for the same finite resources.

According to State Land Cadastre of Ukraine (n.d.), Ukraine's total land area amounts to 60.4 million hectares, of which 42.4 million hectares are classified as agricultural land (roughly 32 million hectares cultivated annually). Built-up areas occupy approximately 2,550.4 thousand hectares, while industrial parcels – encompassing, among other sectors, the food industry – amount to 224.1 thousand hectares. At the national level, annual land-lease costs average 3,518 UAH per hectare. Region-specific data, however, show some variation: in Kyiv, lease rates stand at 2,694 UAH per thousand hectares, whereas in the surrounding Kyiv region – 3,474 UAH per thousand hectares. Taken together, until 2023, these leases collectively generated an estimated 195 million UAH annually in revenues for local budgets.

Table 4 provides a concise overview of Ukraine's agricultural landscape prior to 2023, highlighting both demographic and economic indicators that set the context for ongoing urbanisation trends and shifting land-use patterns. According to these data, nearly 69.41% of the population resides in urban areas, while only 30.59% remains rural. Of a total national land area of 60.4 million hectares, 42.4 million hectares are allocated to agriculture, although merely 224.1 thousand hectares are devoted to industrial activities – including food processing. The built-up portion of Ukraine's territory reaches 2,550.4 thousand hectares, illustrating its expansive infrastructural development alongside its substantial agricultural base.

Table 4. Ukraine agricultural profile data (2022)

Indicator	Value
Urban population	69.41%
Country (rural) population	30.59%
Total area of land plots (million hectares)	60.4
Agricultural land (million hectares)	42.4
Built-up land plots (thousand hectares)	2,550.4
Industry (incl. food processing) (thousand hectares)	224.1
Land rental price (UAH)	185,714,285
Annual salary of agricultural workers (UAH)	81,600
Monthly salary (UAH)	6,800
Land lease per year per hectare (UAH)	3,518
Monthly salary of agricultural workers (UAH)	14,000
Monthly salary in food processing (UAH)	16,500

Table 4, Continued

Indicator	Value
Revenue share of agricultural enterprises	~80%
Revenue share of small farm enterprises	12-13%
Revenue share of private farms	~20%
Food spending as share of total spending	46.6%
Expenditure on meat products per person per year (UAH)	5,487.4
Expenditure on milk per person per year (UAH)	2,746.4
Expenditure on bread per person per year (UAH)	3,750.08
Average per capita food spending in Kyiv (UAH)	25,439.46 (53%)
Average per capita food spending in Kyiv region (UAH)	27,803.04 (54.5%)
Agriculture's rank in national GDP	3rd (~1.7%)
Gross wheat yields (c/ha)	40.2 (160% increase)
Gross barley collection (thousand tonnes)	770 (-8.5%)
Primary focus of large agricultural enterprises	Grain exports (corn, wheat)
Primary focus of households	Oats, millet, rye, buckwheat

Source: calculated by the authors based on State Statistics Service of Ukraine (n.d.)

Based on research and oversaturation, annual land lease rates average 3,518 UAH per hectare, a figure that both underscores the economic significance of farmland and signals its vulnerability to urban-driven increases in land values. Average annual salaries hover around 81,600 UAH, with monthly earnings at 6,800 UAH, although the agricultural sector and food processing industries record higher monthly wages (14,000 UAH and 16,500 UAH, respectively) (Kyiv Statistics Service, n.d.).

Large agricultural enterprises capture the majority of revenue – roughly 80% – mainly through grain exports (notably corn and wheat), while small farm enterprises account for 12-13% and private farms for around 20%. Spending on food constitutes 46.6% of total household expenditures, indicating the centrality of agriculture and food processing in the national economy. Agriculture ranks as the third most significant contributor to Ukraine's GDP, at approximately 1.7% (Kyiv Statistics Service, n.d.; State Statistics Service of Ukraine, n.d.).

Despite these robust indicators, the growing urban population continues to draw labour away from rural areas, compounded by the out-migration of approximately 2.5 million Ukrainian workers to neighbouring countries (Open Data Portal of Ukraine, n.d.). Nonetheless, foreign and domestic investment remains strong in and around Kyiv, with numerous companies and international corporations establishing operations within a 50-kilometre radius of the capital. This intensifying economic focus in metropolitan and peri-urban zones exerts mounting pressure on surrounding farmlands – precisely those territories most prone to conversion as residential, industrial, and commercial developments expand outward. This tension between urban growth and agricultural preservation is central to understanding the current trajectory of land use in Ukraine and the evolving character of its agri-food sector.

Figure 2 illustrates Kyiv's population growth and median income levels in the agricultural and food processing industries. The data indicate a consistent upward trend in population size, coinciding with rising median incomes in both industries. Notably, incomes in the food processing sector (16,500 UAH monthly) consistently exceed those in agriculture (14,000 UAH monthly), reflecting greater economic incentives within urban industries. These income disparities likely contribute to labour migration trends from agricultural to urban sectors, emphasising the economic pressure driving urban expansion and land-use transformation within the Kyiv agglomeration. This demographic and economic intersection underscores the critical need for balanced urban-rural development policies to maintain agricultural viability amidst rapid urbanisation.

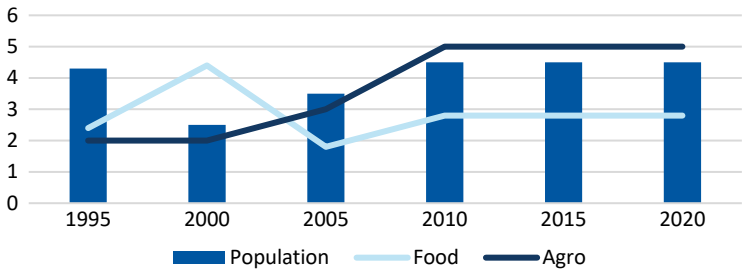

Figure 2. Kyiv population by year, median income (per agricultural, per food processing industries), thousand people and UAH

Source: developed by the authors based on Kyiv Statistics Service (n.d.), State Statistics Service of Ukraine (n.d.)

Table 5 highlights the scale of Ukraine's agricultural output across three core categories – meat, milk, and bread – and underscores the considerable volume that extends beyond domestic demand. The difference between total production and internal market sales indicates Ukraine's capacity to meet its own needs and remain a key supplier in export markets. The study highlights that meat production stands at 53.6 million tonnes per year, of which 43.3 million tonnes are sold on local markets. This leads to the conclusion that more than 10 million tonnes are available for export or alternative channels. Milk and milk-product output is even more pronounced, at 200.5 million tonnes annually, with 141.95 million tonnes consumed within Ukraine, leaving nearly 60 million tonnes for potential external trade. The bread and sub-product segment is most striking: out of 97.6 million tonnes produced, just 20.34 million tonnes reach the domestic market. This gap underscores the importance of export-led production and the scale of processing industries that may add value before shipment abroad.

Table 5. Ukraine's average annual agricultural and farming enterprise data

Production type	Produced, mln tonnes per year	Sold in internal market, mln tonnes per year
Meat and its products	53.6	43.3
Milk and its products	200.5	141.95
Bread and sub-products	97.6	20.34

Source: calculated by the authors based on State Statistics Service of Ukraine (n.d.)

In this study, such figures emphasise the critical need to preserve adequate farmland and maintain robust supply chains, especially in regions experiencing rapid urban expansion like the Kyiv agglomeration. As more agricultural parcels face pressure for residential, commercial, or industrial development, concerns arise about whether Ukraine can sustain these high production levels in the long term. Any significant reduction in arable land could disrupt internal food security and export earnings, particularly for staple goods such as bread, which already display a large surplus above domestic consumption.

The data further suggest that profitable industries – such as meat and milk production – may intensify the operations to meet global demand. However, intensification usually requires more significant swaths of farmland, modernised infrastructure, and an available labour force – factors that can become constrained if urban sprawl continues unchecked. These points reinforce the article's central premise: strategic land-use governance and balanced urban-rural planning are imperative to ensure Ukraine's ongoing role as a major agricultural producer and to protect the viability of critical food sectors in the face of metropolitan growth.

In conducting the presented economic modelling of agricultural and food-processing enterprises in the Kyiv region, particular emphasis

is placed on the land market and associated operational costs. One critical variable is the average annual rent per hectare of land, depending on whether the enterprise is in an industrially zoned district or a more dispersed, rural settlement. In addition, the fact that many of these enterprises aggregate the production capacities in a single complex (i.e., a consolidated site encompassing processing, storage, and sometimes administrative facilities) makes the location decision even more pivotal. Proximity to key markets, labour pools, and infrastructure can substantially lower transportation expenditures and bolster overall profitability, albeit at higher land prices and rental rates.

Figure 3 illustrates the Kyiv metropolitan territory's economic division and pinpoints agricultural enterprise distribution. A noteworthy concentration of food industry facilities – 16 in total – resides within the administrative bounds of Kyiv. This high clustering reflects several regional advantages: enhanced access to urban consumer markets, established infrastructure networks, and better opportunities for technology transfer. However, these same advantages correspond to higher overhead, including elevated land and lease costs, relative to peripheral districts.

The data summarised in Table 6 offer more profound insight into the broader socio-economic environment shaping agricultural activities in the Kyiv region. Within Kyiv, the population is approximately 2.97 million, while an additional 1.78 million reside in the surrounding region. Crucially, about 86% of the total inhabitants in the administrative area around Kyiv are classified as urban, yet the region itself – encompassing 24 smaller villages – still reports 62% of its population living outside major city centres. This demographic structure hints at a potential labour divide: an urban workforce more inclined to seek higher-paying industrial or services-oriented jobs and a rural workforce more likely to engage in conventional or small-scale farming.

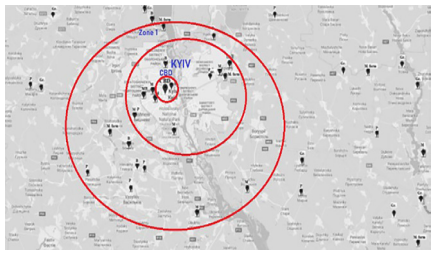

Figure 3. Kyiv economic territorial division map with agricultural enterprise locations
Source: developed by the authors

Table 6. Kyiv region's economic profile and agriculture enterprise data (2022)

Data	Kyiv city	Kyiv region
Population, Kyiv, thousand people	2,967	1,781
Urban population, % of total region	86	—
Non-urban population, % of total region	—	62 24 (small villages)
Average annual wage in agricultural companies, UAH	156,000	126,000
Average annual wage in food companies, UAH	204,000	156,000
Number of agricultural companies in Kyiv and region	16	1,470
Number of agricultural enterprises	6,568	

Note: "—" means no data available
Source: calculated by the authors based on data from Kyiv Statistics Service (n.d.), State Statistics Service of Ukraine (n.d.), State Land Cadastre of Ukraine (n.d.), Open Data Portal of Ukraine (n.d.)

The annual average wage in local agricultural companies is 156,000 UAH in Kyiv. However, it dips to 126,000 UAH in the broader region, reflecting regional cost-of-living variances and differences in job specialisation. Notably, food industry salaries are higher on average – 204,000 UAH in the city and 156,000 UAH in the outlying area – mirroring the value-added

nature of processed goods and the need for technical expertise in these segments, despite the relatively small absolute number of agricultural companies operating directly in Kyiv (16), the surrounding region hosts as many as 1,470 such entities. Meanwhile, the total count of agricultural enterprises in the entire region surpasses 6,500 – reaffirming agriculture's significance even amid intensifying urbanisation.

Land and labour costs must also be evaluated, along with logistics and transportation expenses, as these can significantly shape net operating margins. Regional data reveal that a 20-22-ton van costs about 27 UAH per kilometre outside Kyiv, whereas a 10-ton vehicle costs 20 UAH per kilometre. Within city limits, any capacity can result in a charge of roughly 250 UAH per kilometre, reflecting congestion, higher wages, and administrative fees (Nazarenko, 2021).

Table 7 presents an overview of transport costs by product type and capacity. For instance, poultry farms typically employ refrigerated trucks ranging from 7 to 12 tonnes, while milk farms often use 8- to 10-ton vehicles that incur roughly 27-30 UAH per kilometre. Bread and grain producers, on the other hand, frequently rely on heavy vans (25 to 55 tonnes), with cost estimates at 2.3 to 2.8 UAH per kilometre for medium- or long-haul distances (21 UAH for every 100-200 km). Given that average transport within Kyiv requires about 1.5 hours over an 18.75 km distance, and enterprises located just outside the city typically lie around 18.25 km from the urban boundary, proximity to final markets and raw material sources can drastically influence operating budgets.

Table 7. Kyiv region's economic profile and agriculture enterprise data (2022)

Production category	Transport capacity	Transportation price, per km. $
Poultry	Refrigerators: 3 tonnes; 5 tonnes; 7 tonnes	1-1.2
Milk production	Refrigerators: 3.5 tonnes; 5 tonnes; 20 tonnes	$9 for rent and $1.3 per km
Grain production	Heavy transport vans: 25 tonnes; 55 tonnes	0.8

Source: calculated by the authors based on data from Kyiv Statistics Service (n.d.), State Statistics Service of Ukraine (n.d.), State Land Cadastre of Ukraine (n.d.), Open Data Portal of Ukraine (n.d.)

Figure 4 illustrates the annual agricultural production and consumption trends of key food products – meat, milk, and bread – in the Kyiv region. The graph highlights a consistent surplus in production over consumption, especially in the categories of milk and bread, underscoring the region's potential as a key supplier for both domestic markets and export channels. However, the widening gap between production and internal consumption also signals growing pressure on infrastructure, distribution systems, and land resources, particularly as urban development reshapes regional agricultural capacity. The data presented in Figure 4 are limited up to 2019. The study focuses on comparative historical data, emphasizing significant land use and economic shifts that occurred before and around that period. The authors selected this cutoff to identify long-term trends and patterns before more latter-day disruptions, including those from economic instability or geopolitical events after 2019. Thus, the chosen temporal limitation allows for a more precise, undisturbed analysis of agricultural production and consumption dynamics without the confounding influences of later events, ensuring accurate trend interpretation and policy recommendation formulation.

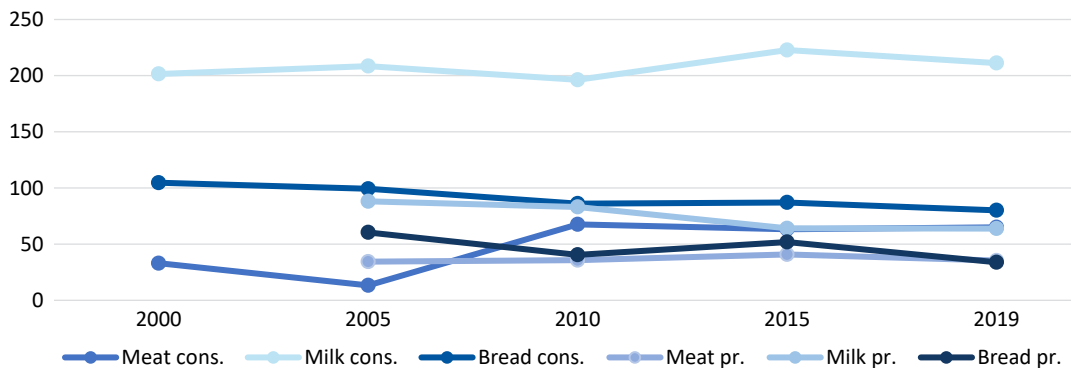

Figure 4. Agricultural production and derivative product consumption, per year (Kyiv)
Source: developed by the authors based on data from Kyiv Statistics Service (n.d.), State Statistics Service of Ukraine (n.d.)

Transportation expenses significantly shape the profitability of agricultural and food-processing operations. Depending on load capacity, per-kilometre charges can range from 20-30 UAH outside Kyiv to as high as 250 UAH per kilometre within city limits for certain vehicles. Grain producers typically pay 2.3-2.8 UAH/km for heavy carriers, whereas poultry and dairy sectors rely on refrigerated trucks, incurring up to 30 UAH/km. Given that the average distance from suburban enterprises to central Kyiv is roughly 18.25 km, these logistics costs can swiftly escalate. As farmland transitions to commercial or residential use, logistics corridors shift accordingly, implying further transportation patterns and expenditure adjustments over time (Nazarenko, 2021).

From an economic perspective, these cost differentials underscore how a strategic location – balancing lower land rent on the metropolitan periphery with proximity to logistical arteries – can substantially improve profitability. Enterprises engaged in high-value production, such as specialised food processing, may be able to absorb higher city-based rents in exchange for swifter access to urban consumer markets and skilled labour. Conversely, bulk commodity producers might find it more cost-effective to situate themselves in outlying districts where real estate is cheaper despite incurring additional transport charges.

The research revealed a significant and ongoing reduction in agricultural land within the Kyiv agglomeration, with agricultural areas constituting only 0.21% of total regional land, while green zones dominate over 54%. High land rents in the metropolitan core – reaching up to 25 million UAH per hectare per year – and substantial wage disparities between urban and rural sectors are major drivers of land-use change and labour migration. Agricultural enterprises, especially in peri-urban zones, face rising operational costs due to logistical expenses and land competition, further threatening the viability. Despite these pressures, the region still supports over 6,500 agricultural enterprises, underscoring the sector's resilience. The findings confirm that without strategic land-use governance, zoning regulations, and supportive economic incentives, urban expansion will continue to erode agricultural capacity, posing risks to food security and balanced regional development. These outcomes highlight the need for integrated territorial planning to reconcile economic growth with the sustainable use of agricultural resources.

DISCUSSION

The results of this study confirm the intensifying competition between urban development and agricultural sustainability in the Kyiv agglomeration. The analysis of land-use data, wage differentials, and enterprise structure revealed a distinct trend: agricultural land is being rapidly marginalised due to increasing land rents, urban infrastructure expansion, and labour migration toward more profitable urban sectors. These conclusions align with findings from several international and national studies, which

emphasise similar pressures across different urbanised regions.

For instance, N. Vasylieva & H. James (2021) demonstrated that urban growth in Ukraine leads to physical and functional restructuring of agricultural territories. The authors found that food production systems near urban centres experience higher risks of displacement unless supported by clear spatial policies. This observation is consistent with this study's findings regarding the drastic reduction of agricultural land to just 0.21% of the Kyiv region and the increasingly high rent of 25 million UAH per hectare in central urban zones. Both studies underline the need for proactive territorial governance.

Research by V. Beckers *et al.* (2020) on Belgian peri-urban areas identified that urban encroachment causes land fragmentation and logistical inefficiencies, reducing farm productivity. This directly mirrors the observed situation in Kyiv, where smaller farms in suburban zones face elevated transport costs and infrastructural bottlenecks. However, unlike Belgium, where compensation mechanisms partially offset these effects, similar mitigation policies were not found to be effectively implemented in Ukraine, highlighting a key divergence.

W. Oueslati *et al.* (2019) examined urban pressures in European cities and found that agricultural land values rise faster than the productive output, leading to land abandonment or conversion. This economic mismatch was also evident in the Kyiv region, where the average enterprise revenue (30.7 million UAH annually) could not compete with speculative land development profits. The comparison reinforces the economic drivers behind farmland conversion.

In the U.S. context, S. Rogus & C. Dimitri (2015) emphasised the persistence of peri-urban agriculture supported by institutional frameworks and local food networks. The work showed that policy-driven support can enable farming to coexist with metropolitan functions even under urban pressure. This contrasts with the Kyiv agglomeration, where no comparable institutional support exists, leaving small and medium agricultural enterprises vulnerable. While both regions face spatial challenges, the U.S. case study offers policy models potentially applicable to the Ukrainian context.

Researchers B.A. Willaarts *et al.* (2013) analysed Brazil's urban expansion, noting how demographic and dietary shifts amplify the pressure on productive land. The work highlighted environmental degradation as a side effect of uncontrolled urban sprawl. Although the present study did not directly evaluate environmental factors, it revealed similar socio-economic drivers – such as rising population densities and infrastructural investments – that threaten land sustainability. The studies share a standard view of the multidimensionality of urban growth impacts.

O. Kravchenko *et al.* (2020) investigated Ukraine's socio-economic transformation in the context of sustainable agricultural development. The authors found that rural underinvestment and population decline compromise agricultural resilience. This aligns with the current findings on the wage disparities and workforce shifts from agriculture to urban industries. While O. Kravchenko *et al.* focused on broader national patterns, the present study provides a focused regional case study that confirms and elaborates on the conclusions. V. Nazarenko (2021) examined the spatial reconfiguration of food-processing enterprises in Kyiv and showed how logistics, rent, and labour availability drive location decisions. These findings correspond closely with this study's empirical results, particularly the clustering of 16 food industry enterprises within Kyiv city borders, where access to urban markets and infrastructure offsets higher rental costs. Both studies demonstrate the selective spatial advantages urban agribusinesses enjoy compared to peripheral producers.

Research A. Kucher (2017) argued that rational land-use planning is a cornerstone of rural development in Ukraine. The author proposed integrating agriculture into regional planning frameworks, a strategy not yet evident in the Kyiv agglomeration. This study's data suggest that without such integration, urban expansion continues to consume productive land without consideration for long-term agri-economic sustainability. The alignment between A. Kucher recommendations and the current study's findings underscores the gap between academic proposals and policy implementation. While F. Martellozzo *et al.* (2018) modelled future land-use change in Italy and predicted severe

agricultural land losses under current policies, the authors also emphasised that strong urban containment strategies can reverse the trend. The model-based approach complements the empirical approach of this study, offering a forward-looking perspective that echoes the conclusions drawn from the Kyiv region's latest historical land transformation.

S. Tripathi & C. Rani (2017) examined the mutual influence between agriculture and urbanisation in India, emphasizing how urban expansion can shape and reshape agricultural activity. The study highlights policy implications for balanced regional development and land use planning. G.F. Winfield (1973) offers a foundational perspective on the impacts of urbanisation on agricultural processes, focusing on land conversion, labour shifts, and market access. Although dated, the article remains relevant as a theoretical framework for understanding long-term urban-agricultural transitions. D. Satterthwaite *et al*. (2010) comprehensively review urbanisation's global implications for food and farming, particularly in developing countries. The authors emphasise that urban growth can disrupt rural food systems while creating opportunities for innovation in urban agriculture and food distribution.

I.E. Okoli *et al*. (2016) explored the economic effects of urbanisation on sustainable food production in sub-Saharan Africa. The study identifies key threats to food security and agricultural land due to urban sprawl and stresses the need for integrated urban-rural policy strategies. D. La Rosa *et al*. (2014) proposed a methodological framework for sustainable urban agriculture planning, focusing on integrating agricultural functions into urban landscapes. The work supports the idea of multifunctional land use and the potential of urban agriculture to contribute to food security, ecological resilience, and social inclusion.

Studies reinforce the observed dynamics of land use and urban transformation in the Kyiv agglomeration. For instance, S. Sakhniuk *et al*. (2023) conducted a geospatial analysis using Landsat satellite imagery to calculate impervious surface indices, revealing a steady expansion of urbanised zones in Kyiv over the last two decades. The findings confirm the growing pressure on surrounding agricultural and green spaces, consistent with the land-use reductions identified in this study. From an ecological and policy standpoint, O. Kramarov (2019) and L. Moldavan *et al*. (2023) emphasised the importance of adapting Ukraine's agricultural sector to contemporary challenges, including climate change and urban encroachment. The authors advocate for integrated sustainable development strategies that combine environmental resilience with socio-economic planning – an approach that aligns with the urgent need to protect agricultural land in metropolitan regions. Moreover, P. Saik *et al*. (2024) proposed a structured ecosystem-based land-use planning framework to achieve land degradation neutrality (LDN) across Ukraine. The research underlines the necessity of balancing development with long-term soil and landscape sustainability, particularly in regions facing accelerated urbanisation. These perspectives support this study's conclusion that policy interventions must go beyond economic zoning to incorporate ecological value assessments and spatial regulation mechanisms.

These findings validate the patterns observed in the Kyiv region and highlight a broader need for integrated, forward-looking planning that can ensure food security, environmental stability, and sustainable urban-rural coexistence. Across these works, several common themes emerge: the spatial displacement of agriculture under urban pressure, the inadequacy of regulatory frameworks, the economic disadvantages of farming compared to industrial sectors, and the sociodemographic shifts favouring urban employment. This study contributes to this body of knowledge by offering a data-rich regional case study and highlighting the direct financial, spatial, and labour-market mechanisms driving agricultural marginalisation. However, differences also appear. Unlike contexts such as Belgium or the United States, where policy instruments partially protect peri-urban agriculture, the Ukrainian case demonstrates a relative policy vacuum. Moreover, while some studies emphasise environmental degradation, the current work focused primarily on economic and spatial parameters, suggesting a potential area for future research.

CONCLUSIONS

The findings of this study emphasise the urgent need for policymakers to adopt a proactive and balanced approach to land-use regulation in the Kyiv agglomeration. The intensifying pressure from urban development on agricultural territories threatens the economic sustainability of local farming enterprises but also the long-term food security of the region. Effective spatial planning, zoning policies, and targeted economic incentives – such as tax benefits, infrastructure support, and land preservation programs – are essential to mitigate land conversion trends and sustain a viable agricultural sector amid continued metropolitan growth.

Contrary to earlier views, the Kyiv agglomeration contains large tracts of farmland, representing the primary urban expansion reserve. Of Ukraine's 60.4 million hectares, 42.4 million are agricultural, with 32 million cultivated yearly; in the Kyiv region alone, 1,470 agricultural companies operate in suburban areas. Given that average land rent (3,474 UAH/ha) is lower outside prime urban zones, farmland conversion incentives remain strong. Meanwhile, agricultural wages (126,000-156,000 UAH yearly) lag food-processing salaries (156,000-204,000 UAH), prompting rural-to-urban migration. Lower labour productivity, suboptimal rural living conditions, and the ongoing security crisis intensify this exodus, undermining agriculture's labour pool and competitiveness.

A cluster of 16 major food-industry enterprises located in the city of Kyiv benefits from agglomeration economies such as immediate access to a market of nearly three million residents, robust infrastructure, and proximity to financial institutions. These advantages help offset elevated land rents, which can reach tens of millions of hryvnias per hectare in premium urban zones. By contrast, peripheral farming enterprises – numbering over 6,500 in the wider region – may enjoy lower land costs but face comparative disadvantages in marketing, distribution, and professional workforce recruitment. As the region's population now exceeds 4.7 million (2.97 million in the city plus 1.78 million in outlying areas), the allure of the metropolitan core is likely to deepen, further widening the economic rift between urban and rural ventures.

In conclusion, the results of this study reinforce and expand upon existing academic literature regarding urbanisation's impact on agriculture. The results also underscore the urgency of establishing targeted land-use policies, transport infrastructure support, and economic incentives to sustain agricultural viability in metropolitan environments. The comparative analysis confirms the global nature of the challenges while emphasising region-specific nuances that must be addressed through localised policy design and implementation. Future research could explore land-price elasticity using econometric models and examine how farms adapt through higher-value production, technology adoption, or income diversification. It may also assess farmland resilience under urbanisation pressures and identify policy tools – such as zoning regulations and economic incentives – to support and sustain local agriculture.

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CONFLICT OF INTEREST

None.

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Володимир Назаренко
Доктор філософії, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-7433-2484
Андрій Мартин
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-6905-2445

Розвиток міст та аграрна динаміка: оцінка економічного ландшафту Київської агломерації

Анотація. У дослідженні проаналізовано вплив швидкої експансії міст на економічну динаміку сільського господарства в межах Київської агломерації. Авторами було проаналізовано зміни у землекористуванні, рівень заробітної плати, обсягах діяльності підприємств та логістичній інфраструктурі з використанням комплексного набору даних, зібраного з записів національного земельного кадастру, економічних звітів та регіональної статистики до 2023 року. Результати засвідчили про значний тиск на сільськогосподарські території: лише 0,21 % (0,18 тис. га) земель у регіоні станом на лютий 2022 було відведено для сільськогосподарського використання, порівняно з понад 54 % відведено до зелених зон та майже 13 % до житлових категорій. Водночас середньомісячна заробітна плата в харчовій промисловості Києва сягала 16 500 грн, тоді як заробітна плата в сільському господарстві прилеглих районів встановлена на рівні 14 000 грн, що впливає на трудову міграцію з сільського до міського секторів. Крім того, транспортні витрати – від 20 до 250 грн за кілометр залежно від місця розташування та типу транспортного засобу – ще більше впливають на життєздатність підприємства та прийняття просторових рішень. Також помітна розбіжність у ставках орендної плати за землю: за землю в межах столичного ядра Києва орендна плата становила до 25 млн грн за гектар на рік, тоді як у середньому по області – 3 474 грн. Ці фактори сприяють зазіханням на сільськогосподарські угіддя для житлового, комерційного та промислового використання. У дослідженні зроблено висновок, що ефективне управління міським і сільським землекористуванням – за допомогою регулювань зонування, фіскальних стимулів та сталого планування – має важливе значення для забезпечення життєздатності сільського господарства та забезпечення збалансованого регіонального розвитку в умовах постійного зростання столичної інфраструктури Києва. Результати цього дослідження можуть стати основою для стратегічного планування землекористування, спрямовувати заходи для пом'якшення негативного впливу на сільське господарство та сприяти збалансованій динаміці між містом та сільською місцевістю в мегаполісах, що швидко розвиваються

Ключові слова: розширення меж міст; аграрна економіка; зміна землекористування; зростання метрополій; соціально-економічний розвиток; економіка ресурсів

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Anastasiia Kyrychenko*
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-5647-7698

Nataliya Tanklevska
Doctor of Economic Sciences, Professor
State University of Trade and Economics
02156, 19 Kyoto Str., Kyiv, Ukraine
https://orcid.org/0000-0003-2906-4051

Risk management in green logistics within the organic food retail sector using the Ishikawa diagram method

Abstract. Green logistics plays a key role in the sustainable development of the organic food retail sector by reducing the environmental impact of transport and warehousing operations. The study aimed to analyse the principal risks in green logistics and to develop mitigation measures using the Ishikawa diagram method. The article examined the share of organic food products in total retail sales, per capita consumption levels in the global market, the contribution of different countries to organic product sales, and identified the ten leading countries in terms of per capita consumption of organic goods. Between 2018 and 2021, the global share of organic products increased from 1.7% to 2.0%, but declined to 1.9% in 2022-2023. In Ukraine, the share remained at 0.1% before falling to 0.0% in 2022-2023. Particular attention was given to analysing trends in the export of Ukrainian organic products, as well as the dynamics of domestic sales, including breakdowns by product category. In Ukraine's domestic market, sales increased from 21 million USD to 33 million USD, but fell to 17 million USD in 2022. The main risks identified in the field of green logistics include supply instability, high costs associated with environmentally friendly transport, regulatory constraints, and shifting consumer priorities. The most significant challenges relate to a shortage of certified suppliers, low levels of digitalisation in logistics processes, and difficulties in packaging disposal. The proposed measures for optimising green logistics include the implementation of advanced IT solutions, the use of alternative modes of transport, the development of local supply networks, and improved management of reverse logistics. The practical value of the study lies in offering recommendations for retail operators aimed at reducing environmental risks, enhancing the efficiency of logistics processes, and supporting the growth of the organic products market

Keywords: fishbone diagram; environmental logistics; retail sales; risk-based approach; sustainable development

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*Corresponding author

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INTRODUCTION

Contemporary environmental challenges such as global warming, environmental pollution, and the depletion of natural resources necessitate a transformation of business processes towards sustainable development. Within the organic food retail sector, the concept of green logistics plays a pivotal role. It aims to minimise negative environmental impact by optimising the transportation, storage, and packaging of products. At the same time, effective risk management in this area has become critically important for businesses, as it ensures supply chain stability, compliance with environmental standards, and increased consumer trust.

An analysis conducted by O. Nikolaichuk & H. Lavronenko (2023) demonstrated that sustainable trade development is a promising approach to achieving sustainability goals. The advancement of sustainable trade is inextricably linked with the transformation of logistics processes, as these directly influence the efficiency of goods delivery and their environmental impact. Research by M.M. Mamchyn & V.V. Naida (2025) indicated that the retail sector, while playing a key role in providing the population with everyday goods, also exerts a considerable environmental impact. This negative impact is evident across all stages of the product life cycle – beginning with production processes that generate greenhouse gas emissions and consume natural resources, continuing through logistics, packaging, storage, and sales, and concluding with disposal, where a significant proportion of products or packaging ends up in landfills. Thus, retail activity generates a complex environmental footprint, necessitating a reassessment and the adoption of sustainable approaches to the management of goods flows. In this context, researchers R. Hrinchenko & O. Gorlova (2024) emphasised in their study that the integration of environmentally friendly practices into logistics processes enhances operational efficiency, reduces costs, and supports the long-term resilience of businesses amid growing environmental pressures. As noted by V. Skupeiko *et al.* (2022), the more active adoption of green logistics methods in business operations can improve the overall efficiency of logistics processes while significantly reducing their harmful impact on the environment. Specifically, the implementation of environmentally focused solutions in transportation, storage, packaging, and distribution contributes to lower pollutant emissions, more efficient use of energy and material resources, and better environmental performance overall. In addition to the ecological benefits, green logistics aligns more closely with the expectations of modern consumers, who increasingly favour companies that demonstrate transparency and responsibility in their business practices. In the long term, this will also help conserve natural resources and support the development of sustainable supply chains. Y. Salo (2023) argued in her study that green logistics is currently both relevant and in demand in Ukraine and abroad. Considering the potential outcomes of implementing environmentally oriented logistics technologies – including the efficient and rational use of company resources, improved environmental safety, reduced ecological harm, and staff training in environmental matters – it can be concluded that the transition to green logistics is an objective necessity of the present stage. According to the research conducted by N. Hryniv & V. Andrukhiv (2023), many enterprises are offering environmentally friendly market mechanisms, high-tech "green" solutions, and promoting the development of supply chains that do not harm the environment. However, these processes continue to be hindered by the insufficient financial resources available to businesses. As noted by N. Kalycheva & Y. Chuguyev (2024), one of the key drivers of effective green logistics development is the formulation and implementation of targeted policies at national and regional levels. This assertion is supported by a systematic analysis of European Union initiatives, particularly the implementation of the European Green Deal, whose primary aim is to achieve climate neutrality by 2050 through a substantial reduction in greenhouse gas emissions in the transport sector. The study provides a detailed characterisation of public policy instruments, which include both fiscal mechanisms (such as taxes, excise duties, and entry fees for eco-zones) and incentive-based measures (such as financial support for enterprises, the

development of environmental infrastructure, and standardisation and certification initiatives). The importance of international coordination of these measures is also emphasised, as addressing environmental issues at the national level cannot be fully effective without a global revision of logistics supply chains. Therefore, coordinated state policy serves as the foundation for greening logistics processes, implementing innovative technologies, and enhancing the competitiveness of retail enterprises during the transition to sustainable development.

This study aimed to analyse the risks associated with green logistics in the organic food retail sector using the Ishikawa diagram method, and, based on this analysis, to develop recommendations for their mitigation. The research objectives were to examine the dynamics of retail trade of organic food development at both global and Ukrainian levels; to analyse the principles of green logistics within the organic food retail sector; and to justify the methodological and practical approaches to applying the Ishikawa diagram for risk management in this field.

MATERIALS AND METHODS

The study covered the period from 2018 to 2023 and included an analysis of data from the following global regions: Africa, Asia, Europe, Latin America, North America, and Oceania. Statistical data were drawn from open sources, including the national portal OrganicInfo (n.d.) and the annual analytical report The World of Organic Agriculture (FiBL, n.d.), published by the FiBL Institute. At the time of writing, complete or verified data for 2024 had not yet been released by these sources, due to typical delays in official statistical reporting. In light of this, the most recent available data for 2023 were used for the analysis, as they remain representative for assessing the current state of the research subject. The selected sources are leading authorities in monitoring the organic product market and ensuring a high degree of information reliability. The use of these data enabled the formulation of relevant conclusions and reflected the dynamics of key trends while taking into account the specific characteristics of the sector. Additional insights into global organic product consumption (including in Ukraine) were obtained using data from Statista (n.d.). The core of the research is based on sources specialising in the organic product market: Overview of the Ukrainian organic market (2018; 2019; 2020), The world of organic agriculture... (2021; 2022; 2024; 2025), which provide verified and thematically relevant data. Particular attention was given to countries in the European region (Switzerland, Denmark, Austria, Luxembourg, Sweden, Germany, France, Belgium, Norway, and Liechtenstein), due to Ukraine's geographical proximity and the close economic, political, and sociocultural ties that exist between European nations. This focus allowed for a more in-depth examination of the regional context relevant to the national economy and the formulation of practical recommendations. Methods based on absolute and relative values were used to analyse changes in the retail trade of organic food products in Ukraine in comparison with global indicators. The study examined the following indicators: the share of organic food in total retail sales; the monetary value of retail trade in organic food; per capita consumption of organic food products; the share of global sales by country; the export of Ukrainian organic products; and domestic sales volumes by product category. The analysis of these indicators was essential for a comprehensive study of the dynamics of the organic food market, the identification of development trends, and the development of recommendations for managing green logistics risks within the organic food retail sector.

Time series analysis was used as the methodological approach, enabling the identification of market development trends based on data collected between 2018 and 2023. This method involved analysing changes in the volume of organic food sales, per capita consumption of organic food, the share of global sales by country, the export of Ukrainian organic products, and domestic sales volumes by product category. This approach made it possible to identify both cyclical and trend components. The Ishikawa diagram (also known as the fishbone diagram) was used for a systematic analysis of green logistics risks in the organic food retail sector. This method enabled the identification of key factors affecting the efficiency of logistics processes and

establishes cause-and-effect relationships between them. The study identified six main risk categories: human factors, methods, materials, equipment, environment, and financial factors. The use of the Ishikawa diagram allowed not only for the systematisation of risks but also for the development of strategies to mitigate them, thereby enhancing logistics efficiency and reducing environmental impact.

The development of an economic-mathematical model for managing green logistics risks in the organic food retail sector enabled the quantitative assessment of logistics efficiency and the optimisation of costs in accordance with environmental requirements. The proposed model takes into account key parameters, including costs related to eco-friendly transport, storage, and packaging; CO_2 emissions levels; the probability of product spoilage; demand; transport distance; and storage time. The formalisation of the optimisation problem was based on minimising total costs while adhering to environmental constraints, allowing for the identification of effective risk management strategies. The bibliographic method used in this study on green logistics risk management in the organic food retail sector involved the systematisation and analysis of academic sources, along with an examination of statistical data and market trends. Through logical generalisation, specific facts and observations served as a basis for formulating broader theoretical and practical conclusions that can be applied to other contexts and wider categories.

RESULTS AND DISCUSSION

The use of green logistics in the organic food retail sector represents a key direction in sustainable development, integrating environmental, economic, and social dimensions. Route optimisation, the reduction of greenhouse gas emissions, the use of eco-friendly packaging, and the adoption of energyefficient technologies all contribute to reducing negative environmental impact. At the same time, the quality and safety of organic products are supported through environmentally sound methods of storage and transportation. Implementing green logistics strengthens a company's reputation, increases consumer trust, and creates competitive advantages in the market. Moreover, adherence to environmental standards and regulatory requirements helps businesses adapt to legislative changes and facilitates entry into international markets (Andrusenko & Prutska, 2025). Although the introduction of green initiatives may require substantial initial investment, in the long term, they contribute to cost optimisation and improved logistics efficiency. Therefore, green logistics is an essential component of business operations for companies engaged in the sale of organic food products, as it ensures a balance between economic efficiency, environmental responsibility, and consumer expectations.

Retail trade in food products is an important indicator of a society's socio-economic condition. Its dynamics reflect the population's standard of living, influence the formation of tax revenues, and demonstrate broader economic development trends. One segment of this market that is gaining increasing significance is the retail trade of organic food products. Growing interest in healthy eating, rising levels of environmental awareness among consumers, and support for sustainable agriculture are all contributing to the growing demand for organic produce. Moreover, the development of this segment reflects shifts in consumer preferences, indicating a societal move towards higher quality and safer food, while also encouraging the emergence of new business models in the agri-food industry.

The organic products market experienced unprecedented growth between 2018 and 2023. Consumers' reasons for choosing organic products include health benefits, taste, environmental friendliness, safety, and support for local farming (Ashaolu & Ashaolu, 2020). In a study by K.R. Shenoy *et al.* (2024) on the drivers of organic consumption, it was noted that the impact of the pandemic on mental health, emotional stability, and overall mood may have influenced dietary choices and consumption habits. Thus, the rise in the popularity of organic products during 2018-2023 is attributed to increased consumer concern about health, the environment, and food safety. Figure 1 illustrates the share of organic food products in retail sales over the period 2018-2023

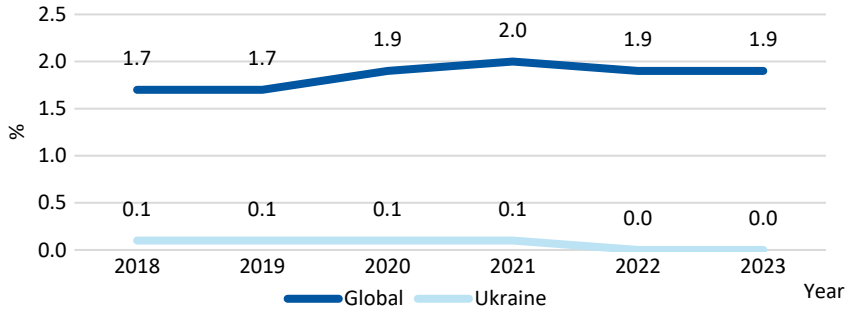

Figure 1. Share of organic food products in retail sales, %
Source: developed by the authors based on data from Food – Worldwide (consumer) (n.d.) and Food – Ukraine (consumer) (n.d.)

Global trends indicate a gradual expansion of the organic food market. In particular, the share of organic products remained stable at 1.7% during 2018-2019, before rising to 1.9% in 2020 and 2.0% in 2021. A slight decline followed, with the figure settling at 1.9% in both 2022 and 2023. This may suggest a stabilisation of demand or reflect the influence of external factors, such as economic fluctuations and shifts in consumer preferences. In contrast, the situation in Ukraine reveals significantly lower figures compared to global trends. Between 2018 and 2021, the share of organic products in retail sales remained at 0.1%, but dropped to 0.0% in 2022 and remained at that level in 2023. The most significant factor behind this decline was the ongoing Russian-Ukrainian war, which led to the disruption of supply chains, reduced production of organic goods, and a reallocation of household spending towards essential items. Other contributing factors included economic hardship, decreased purchasing power, and challenges with organic product certification under martial law. The analysed data highlight clear differences in the development of the organic food market at global and national levels. While the global organic segment continues to show a tendency for gradual growth, Ukraine's market has declined, primarily as a result of the war's impact.

A reliability and sensitivity analysis conducted by R. Daraboina *et al.* (2024) revealed the existence of a multi-segment organic food market. Consumer segmentation based on pairwise comparison results and subsequent cluster validation enabled the identification of three distinct segments: health-oriented, quality-oriented, and value-oriented consumers. The authors concluded that the highest likelihood of switching from organic to conventional products was observed among value-oriented consumers. Table 1 presents the dynamics of organic food retail sales across different global regions between 2019 and 2023, along with changes in per capita consumption.

Table 1. Retail sales and per capita consumption in the global organic market

Region	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Retail sales, million EUR							
Africa**	17.0	16.0	n/a	n/a	n/a	–	–
Asia	10,949	12,540	13,747	15,032	15,471	4,522	41
Europe	45,049	52,000	54,539	53,070	54,749	9,700	22
Latin America*	810	778	778	778	778	–32	–4
North America	48,201	53,717	53,901	64,366	63,920	15,719	33
Oceania	1,378	1,594	1,866	1,510	1,510	132	10
Total	106,404	120,647	124,845	134,760	136,430	30,026	28

Table 1, Continued

Region	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Per capita consumption, EUR							
Africa**	0.01	0.01	n/a	n/a	n/a	–	–
Asia	2.4	2.7	3.0	3.3	3.3	1	38
Europe	55.8	63.2	65.7	64.0	66.0	10	18
Latin America*	1.5	1.2	1.2	n/a	n/a	–	–
North America	132.3	147.5	143.7	171.5	167.0	35	26
Oceania	33.5	38.4	41.9	33.9	33.9	0	1
Total	14.0	15.8	15.7	n/a	17.0	3	21

Note: *Data for Latin America include only Belize, Brazil, Chile, Jamaica, Mexico, and Peru, **Data for Africa include only Ethiopia and Kenya, n/a - not applicable, "-" - no data available
Source: developed by the authors based on The world of organic agriculture… (2021; 2022; 2024; 2025)

The analysis of retail sales confirms the data presented in Figure 1 regarding the overall growth of the global organic food market. In 2019, the total volume of retail sales stood at 106.4 billion EUR, rising to 136.4 billion EUR in 2023 – an absolute increase of 30.0 billion EUR and a relative growth of 28%. The largest contributions to this overall increase came from North America (15.7 billion EUR, +33%) and Europe (9.7 billion EUR, +22%). Asia also experienced notable growth of 4.5 billion EUR (+41%), indicating the rapid development of this market segment. In contrast, Latin America recorded a decline in sales by 32 million EUR (−4%), possibly due to economic difficulties and shifting consumer priorities. The market in Oceania (Australia and New Zealand) remained relatively stable, showing a moderate increase of 10%. Data for Africa for the period 2021-2023 are unavailable, which limits the ability to analyse regional trends in that market. Per capita consumption of organic products also showed a general upward trend. The global average rose from 14.0 EUR in 2019 to 17.0 EUR in 2023, reflecting an increase of 21%. The highest levels of consumption were traditionally recorded in North America, where per capita spending increased from 132.3 EUR in 2019 to 167.0 EUR in 2023 – a 26% rise. In Europe, per capita consumption increased by 18%, reaching 66.0 EUR in 2023. The Asian market also showed dynamic growth – from 2.4 EUR in 2019 to 3.3 EUR in 2023 (+38%). In Oceania, consumption levels remained nearly unchanged, fluctuating between 33.5 EUR and 33.9 EUR. Data for Latin America and Africa are incomplete, making it difficult to conduct a comprehensive analysis of developments in those regions. The results indicate a gradual expansion of the organic food market, with the most notable growth seen in North America, Europe, and Asia. At the same time, certain regions show negative trends or suffer from a lack of reliable data.

Europe holds the second-largest share of organic agricultural land globally, surpassed only by Oceania. Despite the rapid growth in sales, organic production has yet to keep pace with demand: in most European countries, organic farmland accounts for less than 15% of total agricultural land. Liechtenstein has the highest share of organic land in Europe – over 43%. The total area of organic agriculture continues to grow and has already reached 18.5 million hectares (Organic food market in Europe…, 2024).

Figure 2 illustrates changes in the share of individual countries in global organic food sales over the period 2019-2023. The USA remains the market leader, with its share fluctuating between 39% and 43%. After a dip to 39% in 2021, the US share rose to 43% in 2022-2023, indicating a recovery of the country's position in the organic market. Germany has maintained a stable presence, with its share increasing from 11% in 2019 to 13% in 2021. However, it declined to 11% in 2022, before recovering slightly to 12% in 2023. A similar trend is observed in France, where the share gradually declined from 11% in 2019 to 9% in 2022-2023, remaining unchanged in the final two years. Thus, the highest

retail sales of organic food products in Europe are recorded in Germany (15.4 billion EUR) and France (12 billion EUR). In terms of the highest share of organic products in total retail food sales, Denmark, Austria, and Switzerland lead the way. Since 2013, the United Kingdom has seen significant growth in the retail organic food market, which is projected to reach 1.3 billion GBP in 2024 (Organic Food Market in Europe..., 2024). China maintained a market share of 8%-9% throughout the study period, indicating steady development of its organic sector. Canada also showed stable performance, with a slight increase from 3% in 2019 to 4% in 2020, after which the share remained unchanged. The combined share of all other countries gradually declined from 25% in 2019 to 23% in 2022-2023, suggesting a growing concentration of the organic market within the world's leading economies. Overall, the analysis indicates that the key players in the global organic food market continue to be the USA, Germany, China, France, and Canada, while other countries are gradually losing ground in global sales.

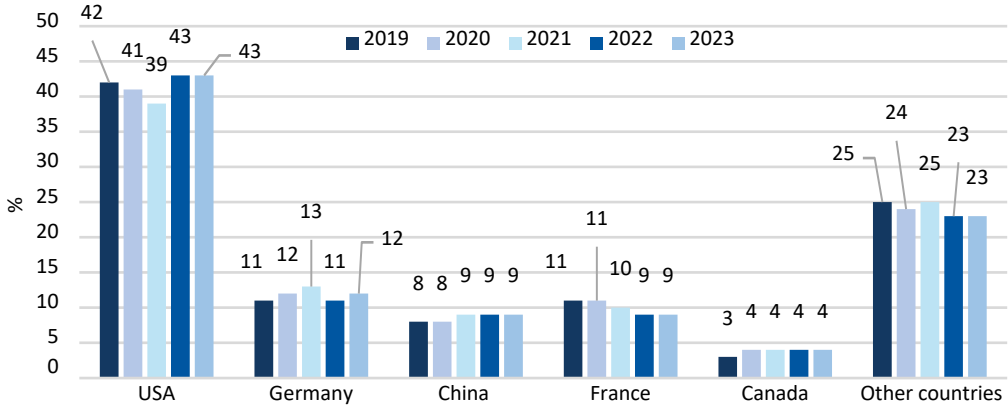

Figure 2. Global market share of organic food sales by country, %
Source: developed by the authors based on The world of organic agriculture... (2021; 2022; 2024; 2025)

Despite Germany having the largest organic food market, the data in Table 2 show that the highest levels of per capita consumption are observed in Switzerland and Denmark. The average organic food expenditure across the EU is approximately 102 EUR per person (Organic Food Market in Europe..., 2024). Switzerland remains the clear leader, recording an absolute increase of 130 EUR or 38% in 2023 compared to 2019. Denmark, which had the highest per capita spending in 2019 (344 EUR), experienced slight fluctuations, with consumption reaching 362 EUR in 2023 – an increase of just 18 EUR or 5%. Austria demonstrates steady growth, with an increase of 76 EUR (35%), indicating a strengthening trend toward organic food consumption. Germany also showed notable growth – 47 EUR or 33% – while France's figures remained almost unchanged (+2 EUR, +1%), suggesting a stable organic food market. The USA and Canada show relatively high growth rates – 26% and 32% respectively – reflecting increasing interest in organic products across North America. In contrast, Luxembourg experienced a decline in per capita consumption by 37 EUR (–14%), while Sweden saw only a marginal increase of 5 EUR (2%). The data for Belgium, Norway, and Liechtenstein are incomplete, as these countries have alternately appeared in and dropped out of the top ten rankings over the years, making it difficult to assess their market dynamics. Overall, countries with traditionally high levels of organic food consumption – such as Switzerland, Denmark, and Austria – continue to lead the market, while some others show inconsistent trends. These fluctuations may be attributed to economic factors, changes in policy support for the organic sector, and the general purchasing power of the population.

Table 2. Countries with the highest per capita consumption of organic products (Top 10), EUR

Country	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Switzerland	338	418	425	437	468	130	38
Denmark	344	384	384	365	362	18	5
Austria	216	254	268	274	292	76	35
Luxembourg	265	265	313	259	228	–37	–14
Sweden	215	212	266	248	220	5	2
Germany	144	180	191	181	191	47	33
France	174	188	187	176	176	2	1
USA	136	148	146	176	172	36	26
Canada	93	112	130	147	123	30	32
Belgium	–	–	–	–	101	–	–
Norway	83	83	–	85	–	–	–
Liechtenstein	–	–	230	–	–	–	–

Note: "-" - no data available
Source: developed by the authors based on The world of organic agriculture... (2021; 2022; 2024; 2025)

The main reasons why European consumers choose organic products include concerns for health and a desire to avoid pesticides and chemical sprays. At the same time, many are unwilling to accept high prices. In 2023, most respondents in the EU reported that food prices had become more important to them over the previous 12 months. This may explain why consumers in many European countries plan to reduce their purchases of organic products. If prices are not adjusted, this trend may persist (Organic Food Market in Europe..., 2024). Ukraine is an important supplier of organic products to the global market, with 99% of its exports in 2023 directed to Europe, demonstrating significant potential in this sector. However, in recent years, there has been a dynamic fluctuation in export volumes, which may be attributed to both internal and external factors (Organic Sales 2016-2023..., n.d.). Figure 3 illustrates the trends in the export of Ukrainian organic products over the period 2018-2023.

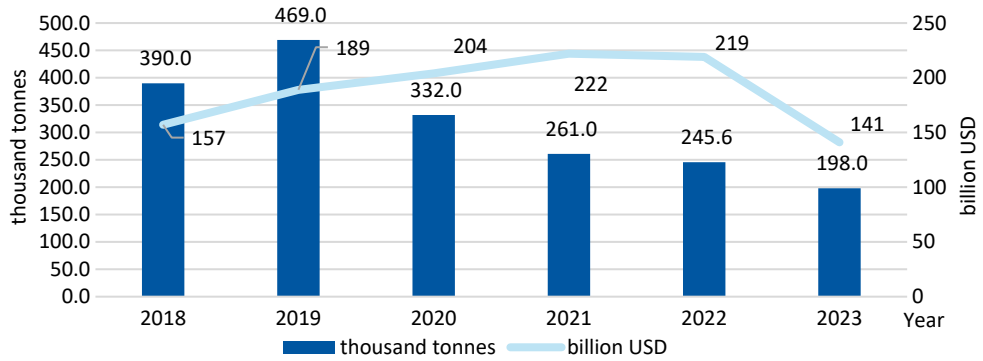

Figure 3. Trends in Ukrainian organic exports
Source: developed by the authors based on Organic sales 2016-2023...(n.d.)

Throughout the analysed period, fluctuations in export volumes are evident in both monetary and physical terms. In 2018, the volume of organic exports stood at 390 thousand tonnes, generating 157 billion USD in revenue. The following year saw an increase in exports to 469 thousand tonnes (+20.3% compared to 2018) and a corresponding rise in revenue to 189 billion USD (+20.4%). The peak in export revenue occurred in 2021, reaching 222 billion USD,

despite a continued decline in the physical volume of exports, which fell to 261 thousand tonnes. This suggests a rise in the average export price or a shift in the export structure towards products with higher added value. From 2022 onwards, export indicators began to show a downward trend. In 2022, the volume of exports amounted to 245.6 thousand tonnes (–5.9% compared to 2021), while revenue fell to 219 billion USD. The most notable decline occurred in 2023, with export volumes dropping to 198 thousand tonnes and revenue falling to 141 billion USD – the lowest figures recorded during the analysed period.

A number of factors contributed to the decline in exports in 2022-2023. Military operations and the blockade of logistical routes significantly hindered the export of food products in general, and organic goods in particular. There may also have been reduced interest in purchasing Ukrainian organic products due to increased competition from other countries or shifts in importers' trade priorities. Currency fluctuations, inflation, and the general economic downturn may have affected the competitiveness of Ukrainian products on global markets. Additionally, reductions in sown areas, shortages of fertilisers and other resources also played a role (Overview of the Ukrainian Organic Market, 2018).

Research conducted by O.P. Karpii & N.R. Struk (2021) indicated that the main consumers of organic products in Ukraine are individuals with medium to high incomes who are informed about the benefits of organic produce. These include young people under the age of 30 and adults aged 45-60 who are concerned about their health and aim to lead a healthy lifestyle. Demand for organic products in Ukraine depends largely on consumer purchasing power, public awareness of the advantages of organic production, and the broader macroeconomic context. Between 2018 and 2023, the domestic organic market showed uneven dynamics (Fig. 4).

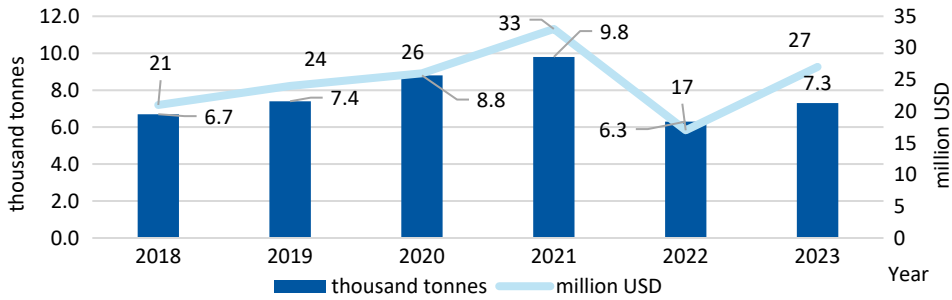

Figure 4. Sales dynamics of organic products on the domestic market
Source: developed by the authors based on Organic sales 2018-2023...(n.d.)

Figure 4 shows that in 2018, total sales amounted to 21 million USD, with 6.7 thousand tonnes of organic products sold. In subsequent years, growing demand led to increased sales volumes: in 2019, 7.4 thousand tonnes were sold (+10.4% compared to 2018), and in 2020 – 8.8 thousand tonnes (+18.9%). The peak was reached in 2021, with sales totalling 33 million USD and 9.8 thousand tonnes. After steady growth from 2018 to 2021, a significant decline was observed in 2022. Sales volume fell to 6.3 thousand tonnes (–35.7% compared to 2021), and total revenue decreased by 48.5%, dropping to 17 million USD. The main reasons for this sharp decline were: disruptions in supply chains due to the Russian-Ukrainian war; a reduction in consumers' purchasing power owing to macroeconomic challenges and inflation; and a decrease in supply caused by the contraction of organic production as a result of the ongoing war (Overview of the Ukrainian Organic Market, 2018). In 2023, partial recovery of the market was observed – sales increased to 27 million USD (+58.8% compared to 2022), while physical volumes rose to 7.3 thousand tonnes (+15.9%). This recovery can be attributed to the market's adaptation to new economic conditions and rising prices for organic products, which explains the considerable

increase in monetary sales despite only a modest rise in physical volumes.

The conducted study provides grounds to assert that the analysis of the dynamics of Ukraine's domestic organic market between 2018 and 2023 reveals a cyclical development pattern: a period of growth (2018-2021) was followed by a sharp decline in 2022, with partial market recovery beginning in 2023. An examination of the dynamics of both exports and domestic consumption of organic products in Ukraine indicates a predominant orientation towards external markets. Export volumes significantly exceed domestic consumption, which can be attributed both to high international demand for Ukrainian organic products and to the limited purchasing power of the domestic population. Despite fluctuations in export deliveries, there is a noticeable trend of increasing foreign currency revenue during periods of reduced physical export volumes. This may suggest a shift in export structure in favour of higher value-added products. Meanwhile, the domestic market shows uneven performance, largely influenced by the macroeconomic situation, consumer awareness, and the availability of organic products (Organic Sales 2018-2023..., n.d.). Overall, given the scale of exports, it can be concluded that Ukraine plays a significant role in the global organic market. Further development of this segment requires not only continued support from external markets but also stimulation of domestic demand. Table 3 presents the dynamics of domestic sales of organic products by product category.

Table 3. Dynamics of organic product sales in the domestic market by product category, million UAH

Product	Year						Absolute change 2023 vs 2018	Relative change 2023 vs 2018, %
	2018	2019	2020	2021	2022	2023		
Dairy products	345	320	420	550	370	438	93	27
Ice cream****	85	15	9	n/a	n/a	n/a	–	–
Vegetables, fruit, mushrooms**	20	35	25	53	83	259	239	1,195
Groats, cereals, flour, seeds, snacks	80	115	125	122	71	99	19	24
Eggs	n/a	n/a	25	35	24	36	–	–
Juices, beverages, pastes, canned products***	6	15	10	61	27	42	36	600
Assorted oils	n/a	n/a	15	9	4	22	–	–
Meat products	30	30	40	45	35	42	12	40
Other products*	17	35	20	15	9	43	26	153
Spices, sugar	7	10	20	10	4	1	–6	–86
Total	590	575	709	900	623	982	392	66

Note: *Other products include bakery items, dumplings/meat dumplings, sweets (chocolate, candies, fruit leather), honey, tea, and coffee,**Mushrooms were not included in 2018, ***Canned products were not included in 2018, ****Ice cream was listed as a separate category from 2018 to 2020, n/a - not applicable, "-" - no data available
Source: developed by the authors based on the Overview of the Ukrainian organic market (2018; 2019; 2020), Domestic organic market in Ukraine (2021; 2022; 2023)

An assessment of individual product categories (Table 3) reveals several important trends: the most significant growth in sales was observed in the Vegetables, Fruit, Mushrooms category, which in 2023 showed a 1,195% increase compared to 2018. This surge may be attributed to heightened demand for fresh organic produce, an expanded product range on the domestic market, and the development of local farming. Juices, beverages, pastes, and canned products also demonstrated substantial growth (+600% from 2018), indicating increased consumer interest in longer-shelf-life goods. This trend may reflect shifting consumption habits linked to the effects of the RussianUkrainian war. Dairy products have remained a stable segment, with a 27% increase in 2023 compared to 2018. This points to sustained

demand and the ongoing development of domestic production. Meat products showed relatively moderate growth (+40%), which may be due to steady demand combined with limited supply caused by high production costs. Groats, cereals, flour, seeds, and snacks also saw growth of 24% compared to 2018, indicating continued consumer interest in these products. A marked decline was recorded in the Spices, Sugar category, with an 86% drop in 2023 compared to 2018. This may be linked to reduced supply or falling demand for organic spices, possibly due to their relatively high price. The Ice Cream and Assorted Oils categories lack sufficient data for a full analysis.

The development of the domestic organic food market in Ukraine between 2018 and 2023 was shaped by a range of economic, social and environmental factors. These included: increasing public awareness of organic products and their health benefits; macroeconomic instability and changes in purchasing power caused by the Russian-Ukrainian war, which led to a decline in sales; localisation of production and a shift in consumer preferences towards local organic products; and the development of sales channels, including online platforms and farmers' cooperatives. It is important to emphasise that e-commerce plays a crucial role in the retail trade of organic food, as it provides new channels for the sale and distribution of products, thereby enhancing their accessibility to consumers (Ilchuk *et al.*, 2023).

Despite the challenges, the positive trends observed in 2022-2023 highlight the potential for further development of the organic food trade in Ukraine. However, realising this potential will require a focus on improving the efficiency of logistics processes, particularly in the context of green logistics. Given that organic products require specific conditions for transportation, storage and distribution, it is essential to develop mechanisms for minimising risks related to supply instability, logistics costs and environmental requirements. Green logistics, as a concept, aims to reduce environmental impact and ensure efficient resource management within supply chains. However, implementing these principles in the retail trade of organic food products involves a range of risks that demand detailed analysis and effective management. Figure 5 presents a block diagram illustrating the main stages of risk management using the Ishikawa diagram method.

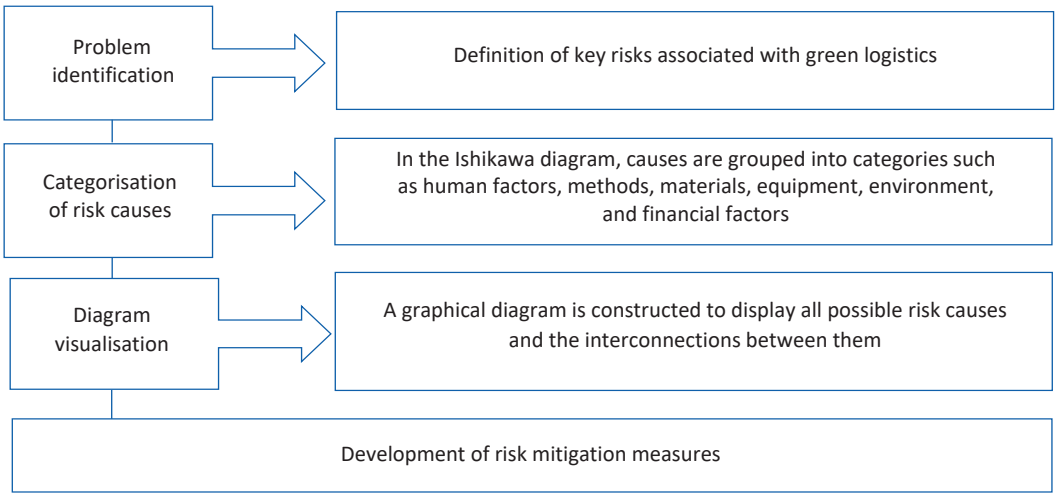

Figure 5. Key stages of risk management using the Ishikawa diagram method
Source: developed by the authors based on their own research

Figure 5 presents a step-by-step process for managing risks in the trade of organic products through green logistics. This includes: defining the problem, identifying key

risks, categorising these risks by type (e.g. human factors, methods, materials, finances, etc.), visualising their interrelationships using the Ishikawa diagram, and developing mitigation measures. At the first stage shown in Figure 5, the key risks associated with green logistics in the organic food trade were identified and are presented in Table 4.

Table 4. Key risks of green logistics in the retail trade of organic food products in Ukraine

Risk category	Type of risk	Risk description
Economic risk	High production costs	The introduction of eco-friendly transport, energy-efficient warehouses and waste reduction technologies requires substantial financial investment
	Exchange rate fluctuations	Most green solutions (e.g. electric vehicles, refrigeration equipment for organic goods) are imported, making their costs susceptible to currency volatility
	Lack of financial incentives	There are no government subsidies or tax benefits for businesses implementing green logistics principles
Logistical risk	Lack of environmentally friendly transport	The limited availability of electric lorries and low-emission vehicles complicates the transportation of organic products in line with green logistics principles
	Underdeveloped infrastructure	There is a lack of specialised green warehouses equipped with energyefficient systems and waste-sorting facilities
	Challenges in maintaining product quality	Organic products have a short shelf life and require specific transport conditions (e.g. temperature and humidity control), creating additional risks of product loss
	Supply chain disruptions	Ongoing military operations, market instability in the transport sector, and rising fuel costs are making logistics processes increasingly unpredictable
Environmental risks	Environmental pollution	Inefficient logistics lead to the spoilage of organic products, resulting in higher volumes of food waste
	High CO_2 emissions	The majority of suppliers rely on conventional transport, which does not meet environmental standards
	Shortage of certified eco-friendly packaging	Sustainable packaging (e.g. biodegradable bags, reusable containers) remains more expensive and less widely available on the market
Technological risks	Lack of digitalisation	Supply chain management systems are underutilised, despite their potential to optimise transport routes and reduce fuel consumption
	Limited access to green technologies	The high cost of energy-efficient equipment, solar panels for warehouses, and other innovative solutions hinders their widespread adoption
Social and regulatory risks	Low consumer awareness	A lack of clear understanding about the benefits of green logistics and its impact on the quality of organic goods reduces consumer demand for such products
	Insufficient government support	There is an absence of targeted programmes for the development of green logistics and a lack of direct incentives for businesses to adopt environmentally friendly solutions
	Shortage of qualified personnel	There is a lack of professionals in the field of green logistics with expertise in sustainable supply chain management

Source: developed by the authors

The next stage in conducting a systematic risk analysis of green logistics involves the use of the Ishikawa diagram method (also known as a "fishbone diagram"). This approach enables the structured identification of key factors affecting the efficiency of logistics processes in the retail trade of organic food products, facilitates assessment of their impact, and supports the development of mitigation strategies. The primary areas selected for analysis include: human factors, methods, materials, equipment, environment, and financial factors (Fig. 6).

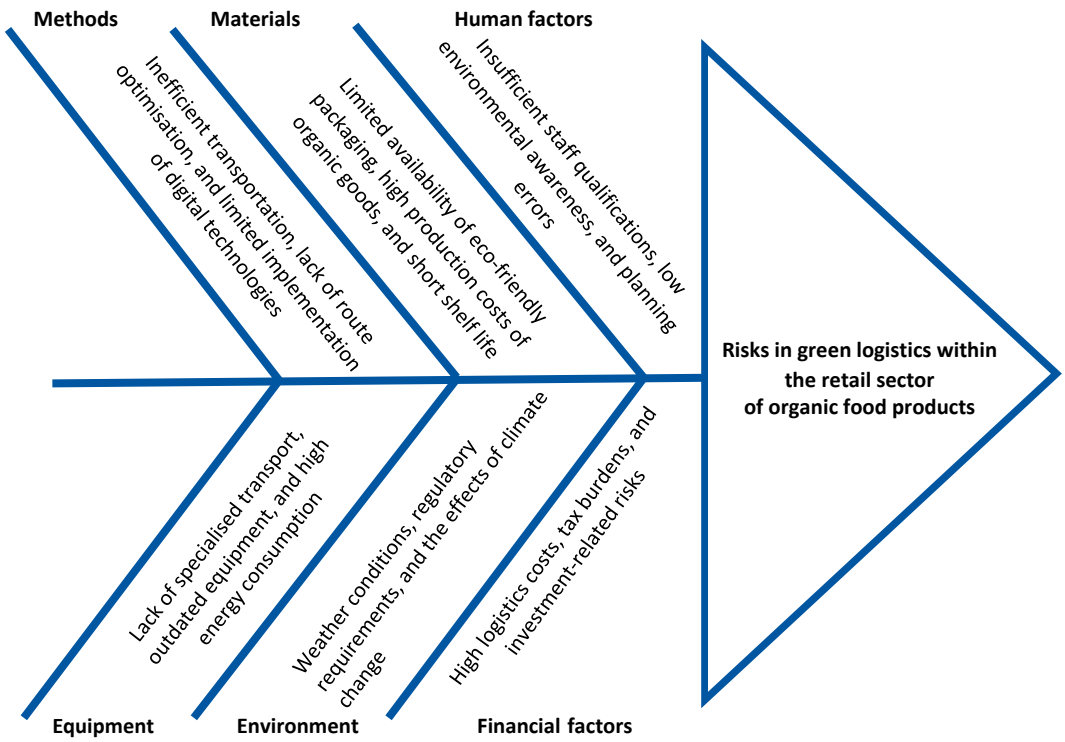

Figure 6. Categorisation of risk factors in green logistics for the retail trade of organic food products using the Ishikawa diagram method

Source: developed by the authors based on their own research

The results of the green logistics risk analysis, conducted using the Ishikawa diagram, enable a systematic identification of the key factors affecting the efficiency of logistics processes. For further research and informed managerial decision-making, it is necessary to develop an economicmathematical model that will allow for a quantitative assessment of logistics efficiency and cost optimisation in line with environmental requirements. Green logistics in the retail trade of organic food products involves the implementation of environmentally sound solutions aimed at reducing environmental impact. One of the core aspects of management is the minimisation of costs while simultaneously reducing environmental risks. Based on the conducted research, an economicmathematical model has been proposed, which takes into account the risks associated with transportation, storage, packaging, and environmental impact.

The green logistics risk management system in the retail sector of organic food products is considered in terms of the following key model parameters: C_{tr} – cost of eco-friendly transport (UAH/km), which includes expenses related to the use of energy-efficient or electric vehicles that comply with modern environmental standards; C_{st} – storage costs for organic products (UAH/day), referring to expenses for maintaining required conditions (temperature, humidity) in warehouse facilities to preserve product quality; C_{pack} – cost of eco-friendly packaging (UAH/unit), covering the use of biodegradable or recyclable materials for packaging organic goods; E_{CO_2} – level of CO_2 emissions per kilometre of transportation (kg/km). It accounts for the environmental burden of transporting goods; P_{damage} – probability of product spoilage. This estimates potential product losses resulting from breaches of storage or transport conditions; D – demand (units of product). This defines the volume of goods that must be delivered to retail outlets; L – transport distance (km). The total distance that must be covered to supply the

products; S – average storage time (days). The duration for which products remain in storage prior to sale. The optimisation problem involves minimising total logistics costs while accounting for risks, and is formalised through the following objective function:

$$F(C_{tr}, C_{st}, C_{pack}) = C_{tr}L + C_{st}S + \\ + C_{pack}D + E_{CO_2}L10 + P_{damage}C_{pack}D, \quad (1)$$

where $C_{tr}L$ is the total eco-friendly transport costs, including expenditure on fuel or electricity and vehicle depreciation. These are determined by the cost of transportation per unit distance and the total distance covered; $C_{st}S$ is the storage costs, ensuring proper conditions are maintained. These are calculated based on the cost per unit of time or volume and the overall storage period or quantity; $C_{pack}D$ is the cost of eco-friendly packaging for all units of product, based on the packaging cost per unit and the total quantity of goods; $E_{CO_2}L10$ environmental costs, which include penalties for CO_2 emissions during transportation. Here, E_{CO_2} is the CO_2 emission per unit of distance, and the multiplier 10 converts emissions into financial or environmental costs; $P_{damage}C_{pack}D$ is the losses due to product spoilage, determined by the probability of damage and the packaging cost per unit of product. The model incorporates minimum environmental standards (model constraints):

$$C_{tr} \geq 400, C_{st} \geq 150, C_{pack} \geq 100. \quad (2)$$

These constraints specify the following: $C_{tr} \geq 400$ UAH/km – minimum expenditure on eco-friendly transport, ensuring compliance with energy efficiency standards. These transport costs are derived from the average cost of transportation using electric or energy-efficient vehicles, including the cost of electricity or biofuel, maintenance, and depreciation. $C_{st} \geq 150$ UAH/day – minimum storage costs required to maintain suitable conditions for organic products. These costs account for maintaining the appropriate microclimate (cooling, humidity control), based on rental tariffs for environmentally certified warehouses. $C_{pack} \geq 100$ UAH/unit – minimum expenditure on eco-friendly packaging, ensuring product safety and compliance with environmental requirements. These costs are based on the prices of biodegradable or recyclable materials commonly used in the industry (e.g. kraft paper bags, cardboard packaging, bioplastics).

Model optimisation makes it possible to determine the optimal cost values that minimise total expenditure while meeting environmental standards. The developed model demonstrates that the implementation of energy-efficient transport, digitalisation of logistics processes, use of sustainable packaging, and route optimisation contribute to cost reduction and mitigation of negative environmental impacts. Applying this model enables evidence-based decision-making in the development of green logistics in the retail trade of organic food products. The proposed economic and mathematical model for managing green logistics risks allows for: determining optimal logistics costs; assessing the influence of environmental factors; and making informed decisions to mitigate risks. The modelling results indicate that effective risk management in green logistics requires a comprehensive approach, encompassing not only cost optimisation but also infrastructural, technological and regulatory reforms. In light of the identified risks, the development of green logistics in the retail trade of organic food products in Ukraine must take into account the author's proposed approaches presented in Table 5.

Table 5. Directions for improving green logistics in the retail trade of organic products in Ukraine

No.	Direction	Brief description / specific measures
1	Expansion of government support	Effective implementation of green logistics requires a supportive regulatory environment. Government assistance through tax incentives, subsidies, and grants would enhance the investment appeal of eco-friendly transport solutions, energyefficient warehouses, and innovative packaging. In addition, mechanisms should be developed to compensate enterprises for the costs of implementing CO_2 emission reduction technologies and recycling eco-friendly packaging

Table 5, Continued

No.	Direction	Brief description / specific measures
2	Development of modern logistics infrastructure	The advancement of green logistics requires the creation of specialised infrastructure, in particular, environmentally oriented logistics centres that comply with energy efficiency principles and sustainable development goals. This involves the construction of warehouses with climate-controlled systems for organic products, the adoption of renewable energy sources such as solar panels and energy recovery systems, as well as increasing the number of low-emission transport vehicles
3	Optimisation of transport routes	The use of digital technologies for supply chain management enhances the efficiency of logistics processes and reduces the environmental footprint. The implementation of transport management systems, geoanalytics, and artificial intelligence makes it possible to minimise fuel consumption by reducing transport distances, limiting vehicle idle time, and optimising cargo space utilisation
4	Attracting investment in environmental technologies	Investment in technological innovation is a key factor in improving the efficiency of green logistics. This includes the introduction of energy-efficient refrigeration units, automated waste-sorting systems, biodegradable packaging, and hydrogen-or electric-powered vehicles. To support this, favourable conditions must be created for both private and international investment in environmental logistics through public-private partnerships and international financial programmes
5	Development of professional education and workforce training	The effective operation of green logistics is not possible without the training of qualified specialists in the field. It is essential to expand educational programmes in logistics to include courses covering the principles of green logistics, emissions management, digitalisation of transport processes, and environmental product certification. A key area of focus is the organisation of practical training and internships for business representatives in the field of sustainable logistics development

Source: developed by the authors based on their own research

Risk management in green logistics is a key factor in ensuring the sustainable development of the organic food market in Ukraine. The proposed measures aim to reduce logistics costs, improve the efficiency of supply chain management, and minimise the negative environmental impact. Implementing these strategic initiatives will contribute to the creation of an environmentally responsible and economically efficient logistics system that meets modern sustainability standards.

According to recent research, despite the challenges posed by the Russian-Ukrainian war, there has been a positive trend in the growth of organic food sales in Ukraine since 2023. This is supported by studies conducted by O. Yatsenko *et al.* (2024) and O. Shpykuliak *et al.* (2024), who stated that the organic market in Ukraine is an actively developing segment of the agricultural sector, reflecting global trends towards healthy lifestyles and sustainable development. In recent years, there has been a steady increase in the production and export of organic products. However, given the current situation in the country, the impact of military conflict and security threats continues to pose serious challenges to the further development of the organic market.

E. Pakhucha & K. Sukhomlynova (2023) argued that Ukraine's organic sector is predominantly export-oriented, with 80%-90% of organic products sold abroad. This is consistent with the findings of this study, which confirm that export volumes significantly exceed domestic consumption. This imbalance is driven both by strong international demand for Ukrainian organic products and by the limited purchasing power of the domestic population. The findings of the study by S. Petrovskyi & I. Horodniak (2025) indicate that the purchasing power of a significant proportion of consumers remains limited, and their willingness to pay a considerably higher price for organic products is low. Most respondents considered it acceptable for the price of organic goods to exceed that of conventional products by no more than 10%. Interest in organic food is most commonly expressed by those who follow a healthy lifestyle; however, financial circumstances remain the decisive factor in purchasing decisions. Effective communication with the target audience should

focus on messages that emphasise care for children and family, alongside clear information about the nature, benefits, and health-enhancing effects of organic products.

Ukraine is a key supplier of organic products to the global market and continues to demonstrate considerable potential in this sector. This is supported by the research of O. Khaietska & D. Udalov (2024), which highlighted that, despite the decline in production and export volumes due to the war, Ukrainian producers are continuing to find ways to supply both domestic and international markets with high-quality organic goods. Ukraine maintains its position among the leading exporters of organic produce to Europe, underlining the significant potential and competitiveness of the Ukrainian agricultural sector on the international stage.

As organic products require specific conditions for transportation, storage and distribution, it is essential to establish effective mechanisms to mitigate risks associated with supply chain instability, logistical costs and compliance with environmental standards. M. Liu *et al.* (2023) confirm that nearly all aspects of food supply – namely, production, storage, processing, distribution, retail and consumption – are susceptible to environmental fluctuations and shock events. These can cause disruptions that cascade through the food supply chain, ultimately affecting geographically distant regions and populations. A common theme in the research is the need to implement digital solutions for the early detection and localisation of risks. F.K. Tetteh *et al.* (2024) asserted that green logistics had become a key strategy in achieving net-zero emissions within supply chains, particularly through the use of alternative fuels, route optimisation, and the reduction of empty mileage. The present study also highlights the potential of green logistics to reduce both carbon footprints and overall costs. P. Trivellas *et al.* (2020) highlighted the need to implement a green supply chain management strategy, which is closely linked to transparent information exchange between partners at all stages – from farm to fork – an integrated logistics network, route optimisation, standardised transport, more environmentally friendly intermodal freight systems, and the adoption of information technologies. This, in turn, enhances operational efficiency and ensures business resilience in a turbulent environment. This view is supported by G. Tian *et al.* (2023), who argued that in light of escalating environmental concerns, low-carbon development has become an inevitable choice. The development of low-carbon sustainability is influenced by a range of factors, including social, environmental, technological, and economic development levels, making the process complex and presenting challenges for decision-making. Both the referenced and present studies acknowledge the multifactorial nature of the low-carbon transition and emphasise the importance of technological investment. The present research contributes to the existing body of knowledge on risk management in green logistics within the retail trade of organic food products. It integrates cost optimisation with the implementation of infrastructural, technological, and regulatory changes.

CONCLUSIONS

The conducted study indicates a growing global demand for organic products, particularly in North America, Europe, and Asia. This trend is driven by increasing consumer interest in health, environmental sustainability, and food safety. At the same time, national markets – especially in Ukraine – are experiencing negative impacts from the war, which has led to a reduced share of organic products in retail sales. Between 2018 and 2021, the global share of organic products in retail increased from 1.7% to 2.0%, but declined to 1.9% in 2022-2023. In Ukraine, the share remained at 0.1% before falling to 0.0% in 2022-2023. Globally, retail sales of organic goods rose from 106.4 billion EUR in 2019 to 136.4 billion EUR in 2023 (+28%), while per capita consumption grew from 14 EUR to 17 EUR (+21%). However, market development dynamics vary across regions. The highest demand remains in developed countries such as the USA, Germany, Switzerland, and Denmark. Conversely, certain nations – including some in Latin America and Africa – are experiencing a decline in sales volumes, largely due to economic challenges and shifting consumer priorities. Taking these factors into account, it can be concluded that the

global organic products market continues to expand, although this growth is uneven and dependent on regional conditions.

Ukrainian exports of organic goods experienced a decline in physical volume, falling from 469 thousand tonnes in 2019 to 261 thousand tonnes in 2021. However, revenue in foreign currency increased, reaching 222 million USD. In the domestic Ukrainian market, sales rose from 6.7 thousand tonnes in 2018 to 9.8 thousand tonnes in 2021, with turnover increasing from 21 million USD to 33 million USD. Nevertheless, in 2022, these figures dropped to 6.3 thousand tonnes and 17 million USD, respectively. Overall, market trends indicate a cyclical pattern, with a peak in 2021, a downturn in 2022, and partial recovery in 2023. In particular, 2023 saw a rebound in domestic sales, made possible by adaptation to new economic realities and shifts in consumer behaviour. However, for the continued development of the organic products market in Ukraine, it is essential to support both the growth of external demand and domestic consumption by improving product accessibility and raising public awareness.

The analysis of green logistics risks in the retail trade of organic food products in Ukraine has made it possible to identify key factors affecting the efficiency of logistics processes and provides a basis for formulating strategies to minimise these risks. The use of the Ishikawa diagram method facilitated a systematic examination of the underlying causes of risks, including economic, logistical, environmental, technological, and social factors. The developed risk categories help assess the interrelations between these factors and identify the most critical areas requiring managerial intervention. In particular, attention should be focused on the development of infrastructure to support green technologies, the implementation of environmentally friendly transport and energy-efficient warehouses, as well as the enhancement of workforce qualifications and the promotion of green logistics among consumers. Future scientific research should explore the actual health benefits of organic products for consumers, along with their environmental and social advantages compared to conventional goods.

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CONFLICT OF INTEREST

None.

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Анастасія Кириченко
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-5647-7698
Наталія Танклевська
Доктор економічних наук, професор
Державний торговельно-економічний університет
02156, вул. Кіото, 19, м. Київ, Україна
https://orcid.org/0000-0003-2906-4051

Управління ризиками зеленої логістики у сфері роздрібної торгівлі органічними харчовими товарами з використанням методу діаграми Ісікави

Анотація. Зелена логістика відіграє ключову роль у сталому розвитку роздрібної торгівлі органічними харчовими товарами, сприяючи мінімізації екологічного впливу транспортних і складських операцій. Метою дослідження був аналіз основних ризиків у сфері зеленої логістики та розробка заходів з їх мінімізації за допомогою методу діаграми Ісікави. У статті досліджено частку органічних харчових товарів у загальному обсязі роздрібних продажів, рівень споживання на душу населення на глобальному ринку, частку різних держав у продажах органічних продуктів, а також визначено десять країн-лідерів за споживанням органічних товарів на душу населення. У 2018-2021 рр. світова частка органічних продуктів зросла з 1,7 % до 2,0 %, а потім у 2022-2023 рр. знизилася до 1,9 %, в Україні ж вона залишалась на рівні 0,1 %, але у 2022-2023 рр. впала до 0,0 %. Особливу увагу приділено аналізу тенденцій експорту української органічної продукції, а також динаміці її продажів на внутрішньому ринку, включаючи розподіл за категоріями товарів. На внутрішньому ринку України продажі зросли з 21 до 33 млн дол., однак у 2022 р. впали до 17 млн дол. Визначено, що основними ризиками у сфері зеленої логістики є нестабільність постачань, високі витрати на екологічний транспорт, нормативні обмеження та зміни споживчих пріоритетів. Найбільші виклики пов'язані з дефіцитом сертифікованих постачальників, низьким рівнем цифровізації логістичних процесів та труднощами в утилізації упаковки. Запропоновані заходи щодо оптимізації зеленої логістики включають впровадження сучасних ІТ-рішень, використання альтернативних видів транспорту, розвиток локальних мереж постачання та покращення управління зворотними потоками товарів. Практична цінність дослідження полягає у формуванні рекомендацій для роздрібних операторів щодо зниження екологічних ризиків, підвищення ефективності логістичних процесів і стимулювання зростання ринку органічної продукції

Ключові слова: діаграма "риб'ячої кістки"; екологічна логістика; роздрібні продажі; ризик-орієнтований підхід; сталий розвиток

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Oksana Perchuk*
PhD in Economics, Associate Professor
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0000-0002-6484-7011
Olena Yosypenko
Lecturer
Hryhorii Skovoroda University in Pereiaslav
08401, 30 Sukhomlynskyi Str., Pereiaslav, Ukraine
https://orcid.org/0009-0008-3537-3073

Analysis of the impact of tax rates and privileges on the accounting of small and medium-sized enterprises in Ukraine: Challenges and opportunities

Abstract. The aim of the study was to analyse the impact of tax rates and privileges on the accounting of small and medium-sized enterprises in terms of existing challenges and opportunities. The tools used were SWOT-analysis, PESTEL-analysis and the case of small and medium-sized farms, which are one of the key sources of national gross domestic product. The analysis revealed a downward trend in the number of small and medium-sized enterprises, which account for more than 99% of all enterprises in the country and employ 81.5% of the total employed population. Since February 2022, about half of small and medium-sized enterprises have ceased operations and another quarter have relocated to other parts of the country or abroad. The temporary reduction of the tax burden on such enterprises to support their sustainable development during the first year of the full-scale invasion had a positive effect. However, the reintroduction of pre-war tax regulations in 2023 significantly worsened their economic condition and became an obstacle to stable development. As of 2024, the majority of small and medium-sized enterprises use the simplified accounting and taxation system, which, however, has drawbacks, including limited eligibility for the simplified taxation system and lack of certainty regarding the calculation of the income threshold for third group enterprises after the termination of the martial law regime. Despite these shortcomings, the system has had a positive impact on the activities of small and medium-sized enterprises, 76% of which declare their readiness for further growth. In order to maximise the benefits of the changed accounting and taxation system, the study offered recommendations to enterprises to seek assistance in choosing a type of activity to reduce the

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*Corresponding author

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fiscal burden, reorganise the accounting department through outsourcing, and continuously analyse business activities to identify and optimise the effects of accounting

Keywords: fiscal policy; fiscal burden; reporting system; sustainable development; reform

INTRODUCTION

Small and medium-sized enterprises (SMEs) are key elements of the business environment, and effective and fair taxation of them is a national priority and a key to sustainable economic development. This statement is based on an understanding of the complex role of taxation, which acts as both an incentive and a deterrent to business development. One of the tasks is to create tax conditions for sustainable development of SMEs, even in unfavourable conditions.

During martial law, special attention is paid to SMEs, given their contribution to the country's economic development, employment and social well-being. The martial law conditions provide for certain changes in taxation, including the simplified tax accounting system (Halaburda & Shevchenko, 2022). An analysis of these changes provides an insight into the challenges and opportunities that SMEs in Ukraine face.

SMEs are a key driver of the country's economy, as they account for over 99% of all enterprises, according to the M. Kuznietsova (2023). S. Skrypnyk *et al.* (2023) illustrate the importance of SMEs by highlighting that they generate 64 per cent of value added and employ 81.5 per cent of the country's total workforce. The value of SMEs for the country's economic development is also reflected in the fact that such enterprises generate more than 55% of the country's gross domestic product (GDP).

V. Loiko & B. Aleksandrov (2023) drew attention to the decline in the number of SMEs, which is an alarming signal for the country's economic development. After analysing statistical data for 2010-2021, the researchers noted that the number of medium-sized enterprises decreased by 16.54% during this period, and the number of small ones – by 10.37%. The full-scale invasion has become another threat to the development of small and medium-sized enterprises in Ukraine. A study conducted by the Ministry of Economy of Ukraine in cooperation with international NGOs (Assessment of the impact..., 2024) found that after 24 February 2022, only 20% of SMEs in the country rated their condition as good or excellent. Approximately 50% of SMEs were forced to suspend their operations, another 20% were relocated within the country, and 4.4% were relocated abroad. Thus, martial law has become a period of testing for Ukrainian SMEs.

Researchers, such as V.B. Vasyuta & A.O. Buryak (2023), however, acknowledge that despite the challenges, SMEs demonstrate a readiness for sustainable development. According to the European Business Association, "Small Business Sentiment Index 2022" survey, 76% of SME owners planned to expand their businesses in 2023 (Despite the war..., 2023). Of the companies that declared their readiness to grow, 28% planned to expand their geographic presence, 26% to open new areas, 25% to enter foreign markets, and another 21% to increase the number of employees. Despite the obstacles of martial law, SMEs demonstrate resilience and readiness for growth.

For some SMEs, the adoption of Law of Ukraine No. 3219-IX (2023), which came into force on 1 August 2023, has become an obstacle to sustainable development. The key provisions of this law are the return of the pre-war taxation system, including the abolition of the 2% single tax rate for individual entrepreneurs (IEs) and legal entities in the third taxation group. The Law also provides for the cancellation of the possibility for sole proprietors of the first and second taxation groups to avoid paying the single tax, except for companies whose tax address is located in the area of hostilities or in the temporarily occupied territories. In addition to these changes, the law partially lifted the moratorium on fiscal audits. With the adoption of the law, a large number of SMEs are experiencing greater tax pressure than at the beginning of the full-scale invasion, which, according to L.M. Karpenko *et al.* (2023), may cause them to cease operations.

During martial law, however, some features of the simplified taxation system proposed to ensure the sustainable development of small

enterprises are preserved. I.V. Sadovska *et al*. (2019) explained the difference between general and simplified accounting by the number of journals used to reflect the economic activity of an enterprise. In the simplified accounting system, in particular, an asset journal, a capital and liability journal, an income journal, and an expense journal are used (Seniv, 2023). SME owners can choose the accounting system that best suits their business. According to O.V. Nikoliuk (2023), the use of different accounting systems is one of the conditions for the development of SMEs in the context of an inclusive economy. According to O.V. Markus & M.O. Sakharuk (2020), one of the key features is the reflection of business transactions in the month of their execution.

Although the peculiarities of SME taxation have been sufficiently studied, changes in tax policy and their impact on accounting processes, management decisions, and financial results in the context of martial law and economic turbulence require additional analysis. The purpose of this study was to identify changes in the country's tax policy since 2019, when a downward trend in the number of SMEs was recorded, and to analyse the impact of the decisions made on the prospects for doing business in the country during and after the end of the martial law regime.

MATERIALS AND METHODS

The research analysed sources that covered a wide range of topics related to taxation, development and support of small and medium-sized enterprises (SMEs) under martial law. First and foremost, these are the Laws of Ukraine that provide the regulatory framework for adapting the tax regime in times of war. In particular: the Law of Ukraine No. 2173-IX (2022) and the Law of Ukraine No. 3219-IX (2023).

The study also used sectoral reports of government agencies and academic institutions submitted in the period from 2022 to 2024. In particular: "Activities of Large, Medium, Small and Micro-Enterprises" by the M. Kuznietsova (2023), "Problems of Small and Medium Business Development in Ukraine as the Main Source of Jobs" by L.D. Yatsenko (2024) from the National Institute for Strategic Studies, and "Assessment of the Impact of the war on micro-, small-, and medium-sized enterprises in Ukraine" (2024). These documents provided empirical data on the state of SMEs, which allowed us to assess their dynamics and key indicators. A limitation of the study was the use of statistical data up to and including 2023, as official statistics for 2024 had not yet been published by the State Statistics Service at the time of writing.

A number of academic articles were also analysed to contextualise the peculiarities of SME taxation, taking into account the prospects for their development under martial law. This provided a theoretical basis for developing recommendations for business support and recovery. The PESTEL analysis method was used as the main research method to understand external macro factors that affect the development of a particular segment, in particular, SMEs (Kung, 2023). The analysis was based on industry reports and academic research. A SWOT analysis of the existing tax rates and exemptions was also conducted in terms of their impact on the accounting of SMEs in Ukraine. The decision to use the general or simplified taxation system, as well as the changes in tax legislation that took place on 1 August 2023, were analysed in terms of their strengths and weaknesses, as well as existing opportunities and threats. The analysis provided insight into the feasibility of changes in the taxation and accounting system to promote sustainable development of SMEs in the changed environment.

In addition to the above analytical tools, a general analysis method was used to study the specifics of accounting and taxation in small and medium-sized farms in the country. This segment of the economy was chosen due to the fact that, according to the Ministry of Finance of Ukraine (2025), the share of farms in national GDP production is about 10%. Farms, including small and medium-sized ones, are the driving force of the national economy and need support from the state. In this study, a comparative analysis of the taxation and accounting system for farms in Ukraine was conducted.

RESULTS

Development of small and medium-sized enterprises in Ukraine

The need to ease the accounting requirements and reduce the tax burden on SMEs is driven by an understanding of their role in the

development of the country's economy. The idea that small and medium-sized enterprises make up the majority of all enterprises in the country is supported by academic sources. According to S. Kulakova & O. Zhytnyk (2023), SMEs generate more than 50% of GDP, i.e. they are the driving force behind the country's economic development. The state has developed criteria for dividing enterprises into four categories: micro, small, medium and large. According to M. Kuznietsova (2023), the division into categories is based on the book value of assets, net income from sales, and the average number of employees. The differences between small and medium-sized enterprises in terms of these criteria are presented in Table 1.

Table 1. Criteria for dividing enterprises into small and medium-sized ones

Criterion	Small business	Medium-sized business
Book value of assets	350 thousand – 4 million EUR	4-20 million EUR
Net income from sales of products (goods, works, services)	700 thousand – 8 million EUR	8-40 million EUR
Average number of employees	10-50 persons	50-250 persons

Source: based on M. Kuznietsova (2023)

The size of an enterprise is a key factor in choosing an accounting and tax accounting system. Such a system, according to S. Skrypnyk *et al.* (2023), is important for creating transparent and equal conditions for the development of enterprises of different types. Based on the data of the State Statistics Service of Ukraine (2024) and the National Institute for Strategic Studies (2024), the trend in the number of small and medium-sized enterprises before the full-scale invasion was analysed, the results of which are shown in Table 2 below.

Table 2. Dynamics of the number of operating SMEs in Ukraine in the period from 2019 to 2023

Year	Medium-sized business	Small business
2019	18,129	1,922,978
2020	17,946	1,955,119
2021	17,811	1,937,827
2022	14,783	1,718,053
2023	13,778	1,899,640

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

Based on the table above, the decline in the number of enterprises, especially medium-sized ones, was already observed before the full-scale invasion, but the armed aggression and the restrictions it caused, in particular the wartime legal regime, exacerbated this trend. For an objective assessment of this trend, it is also worth considering the fact that some of the businesses that ceased operations after the start of the full-scale invasion resumed their operations in 2023. The SMEs that ceased operations were also replaced by SMEs that opened in 2023. In support of this view, O.S. Balan *et al.* (2023) compared the statistics of small businesses started in 2022 and the first half of 2023. The results of this comparison are presented on Figure 1.

Based on the above dynamics, it can be assumed that small and medium-sized businesses have adapted to the changed realities and demonstrated their readiness for sustainable development despite unfavourable external conditions. Table 3 shows an analysis of the macro factors that have influenced the development of SMEs since February 2022, when Ukrainian businesses found themselves in extremely difficult conditions caused by military aggression.

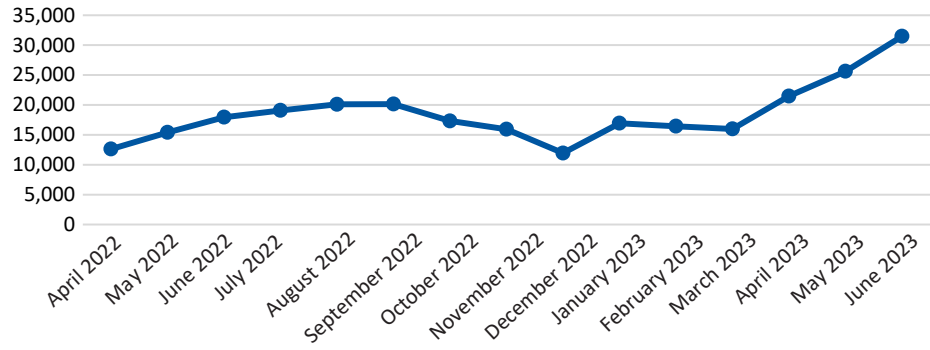

Figure 1. Dynamics of starting new small businesses in Ukraine in 2022 and the first half of 2023
Source: compiled by the authors based on O.S. Balan *et al.* (2023)

Table 3. PESTEL analysis of SME development in Ukraine

Factor	Comment
Political	"The SME Development Strategy until 2027" envisages government support, including through the grant programmes "Your Greenhouse", "New Level", "Your Business", etc. However, the uncertainty caused by the hostilities affects the level of business confidence in the government.
Economic	SMEs are operating against the backdrop of an economic downturn caused by the full-scale invasion. Around 75% of businesses report a decrease in demand, and 20% face late or non-payment from customers.
Social	SMEs are the country's main employer and a source of social stability. The recovery of enterprises that have suffered losses from a full-scale invasion depends on their size: the highest recovery rates are recorded among medium-sized enterprises (Fedorchuk, 2023). The process of recovery and sustainable development of SMEs is affected by factors such as the evacuation of employees, reduction of skilled personnel, reduced purchasing power due to lower incomes, and the re-profiling of some SMEs to meet the challenges of the times, including assistance to the Armed Forces or internally displaced citizens.
Technology	The use of innovative technologies (e-procurement, international business platforms, digital HR management tools) increases the efficiency of SMEs and support their sustainable development (Zolkover & Lyumanov, 2023).
Environmental	Combat operations have a negative impact on the environment, in particular, through the pollution of land, water bodies, etc. This leads to a reduction in the volume or cessation of activities of some enterprises, in particular those specialising in the production of consumer goods. Environmental pollution also makes farming impossible in certain areas.
Legal	Initiatives have been proposed to support SMEs under martial law, including amendments to the Law of Ukraine No. 2173-IX (2022) and a similar law of Ukraine No. 3219-IX (2023).

Source: compiled by the authors based on Law of Ukraine No. 2173-IX (2022), Law of Ukraine No. 3219-IX (2023), V. Fedorchuk (2023), V. Loiko & B. Aleksandrov (2023), A.O. Zolkover & A.S. Lyumanov (2023), the Ministry of Economy of Ukraine (2024)

The analysis shows that since 2022, the number of factors that have a negative impact on SME development has increased. These factors include, in particular, unresolved security issues, economic instability, the forced relocation of some businesses, including abroad, and the cessation of operations in the combat zone and temporarily occupied territories. The development of SMEs is also affected by regulatory issues caused by the martial law regime. An example of such problems is the introduction by the state of a number of

restrictions on the movement of goods and services, which complicates the work of businesses and reduces their competitiveness. The government, for its part, is working on a strategy for sustainable business development amid economic uncertainty. The SWOT analysis helped to understand the internal and external factors that influence the implementation of this strategy. The results of the analysis are presented in Table 4.

Table 4. Analysis of the state SME support strategy

Strengths:	Weaknesses:
■ Variety of loan and grant initiatives to create and support sustainable development of SMEs. ■ Simplified accounting and taxation system.	■ Despite its advantages, the simplified taxation system cannot be applied to all SMEs in the country.
Opportunities:	**Threats:**
■ Introduction of new forms of state support for SMEs. ■ International cooperation to create new support programmes.	■ Closure of SMEs or their relocation abroad. ■ Extension of the wartime legal regime and related restrictions on business activities.

Source: compiled by the authors

Based on the analysis, it can also be argued that despite the unfavourable conditions, SMEs continue to receive the state support necessary for their sustainable development. The SME development strategy approved in 2017 has demonstrated its effectiveness in peacetime. As of 2024, the strategy was revised to take into account the factor of armed aggression and the wartime legal regime. According to the Ministry of Economy of Ukraine (2024), the strategy is implemented for the period from 2024 to 2027 and provides for the restoration and facilitation of the business process, its innovative development and digital transformation, human capital and entrepreneurship development, as well as increased competitiveness and exports. In other words, the state continues to provide comprehensive support to SMEs even in the face of economic and socio-political uncertainty. An example of such support is the state programme "Own Greenhouse" (2024), under which small business owners can receive a grant of up to 7 million UAH to set up a greenhouse complex and purchase the necessary materials. A prerequisite for receiving a grant is an obligation to create at least 40 jobs. Micro- and small business owners can also apply for the "Own Business" programme and receive 250,000 UAH to purchase equipment, raw materials, commercial concessions, etc. Small businesses applying for this programme are required to create at least one job. Some of the state support programmes provide business owners with more freedom in choosing the criteria. For example, the "Own Garden" programme, which provides grants of up to 400,000 UAH on a co-financing basis. A condition for participation in the programme is the obligation to create 6-10 permanent jobs and 125-425 seasonal jobs. In addition to these opportunities, the government has initiated a programme to provide loans for business development at 5-7-9%, with 9 banks participating. These initiatives show that the state continues to support SMEs despite the economic and other losses caused by the military aggression.

Changes in the simplified taxation system for the period of martial law

One of the types of state support for SMEs to promote entrepreneurship is the introduction of a choice between the general and simplified taxation systems. The simplified taxation system reduces the administrative and tax burden on businesses. Taxpayers are divided into several groups depending on the amount of income, number of employees and type of activity. The main advantages of the proposed system are a reduction in the number of tax reports, simplified accounting and payment of the single tax. The differences between the general and simplified taxation systems are shown in Table 5.

Table 5. Features of the general and simplified taxation system for SMEs

No.	Criterion	General taxation system	Simplified taxation system
1	Tax rate	Income tax – 18%; unified social contribution (USC) – 22%; military duty – 5% from 1 January 2024	The single tax depends on the taxpayer's group: Group I – 302.8 UAH; Group II – 1,420 UAH; Group III – 5% of income or 50 UAH per thousand hryvnias
2	Registration as a value added tax (VAT) payer	If the volume of taxable transactions is 1 million UAH	Not a VAT payer, except for group 3 at a rate of 3%
3	Reporting period	Calendar year/quarter	Calendar year for taxpayers of groups 1-2, calendar quarter for taxpayers of groups 3-4
4	Reporting procedure	The declaration is submitted once a year, no later than 9 February of the year following the year for which the report is submitted	The regularity of tax return submission depends on the taxation group

Source: compiled by the authors based on O. Toporkova (2020)

A comparative analysis of the existing accounting and taxation systems suggests that the simplified system is preferred by SMEs, as it is more flexible in taking into account the specifics and needs of modern business. During the wartime legal regime, such flexibility is an important criterion, as many businesses are in a state of uncertainty and need support from the state. Recognising the importance of sustainable development of SMEs for the country's economy, the government has proposed changes to the simplified taxation system. These changes primarily concerned tax accounting, including the submission of a single tax report. The essence of this change was that SME owners were exempted from the obligation to file a single tax return for the period in which the tax was not paid. Another change concerned the submission of a single contribution report and meant that the report was not submitted for the period when the tax was not paid. With the mobilisation, changes were also introduced to the calculation of the unified social contribution for mobilised employees. This change consisted of calculating the unified social tax based on the accrued income up to the maximum amount on which the unified social tax is charged. In addition to these changes, the procedure for paying the single tax was changed; under the new rules, it is to be paid within 10 calendar days following the last day of the relevant deadline for filing a tax return. Changes in the tax accounting system also affected value added tax (VAT), which was exempted for individual entrepreneurs in the third taxation group. Changes in liability for overdue taxes were also important for many SMEs. According to the updated rules in the tax accounting system, taxpayers capable of fulfilling their tax obligations in a timely manner were exempt from such liability. The simplified taxation system also underwent changes, the main ones of which are presented in Table 6.

Table 6. Changes to the simplified taxation system effective after 1 August 2023

Change	Comment
Cancellation of the 2% single tax	Applies to individual entrepreneurs and legal entities for which the tax rate is increased to 5%
Cancellation of the option not to pay the single tax	This option is cancelled for individual entrepreneurs of the first and second groups. An exception is made for companies whose tax address is located in the area of hostilities or in the temporarily occupied territories
Transition period conditions have been established	These conditions define the procedure for switching taxpayers to the general or simplified taxation system. Upon completion of the transition, SMEs lose the right to use taxation benefits
Moratorium on documentary inspections of taxpayers and single social contribution payers extended	This moratorium does not apply to certain types of audits, including budgetary reimbursement, taxpayer's application or complaint, liquidation of a company, disciplinary action, etc.

Table 6, Continued

Change	Comment
Return to the pre-war schedule	This schedule provides for three categories of taxpayers
The right to voluntarily pay the single tax is preserved	This right applies to taxpayers of the first and second groups who have a tax address in the area of hostilities or in the temporarily uncontrolled territories
Exemption from financial liability for violations in the use of payment transaction registers (PTRs)	SMEs that have committed violations in the areas of hostilities or possible hostilities are exempt from liability. However, SMEs that have violated the procedure for making payments when selling excisable goods are not exempt from liability

Source: compiled by the authors based on the Law of Ukraine No. 3219-IX (2023)

Compared to April 2022, the changes to the accounting and tax system as of August 2023 will increase the fiscal and tax burden on SMEs, except for those whose tax address is located in the combat zone, the zone of possible combat operations or the temporarily occupied territories. One of the weaknesses of the current accounting and taxation system is the limited right of application, i.e. not all SMEs can be taxed under the simplified taxation scheme. S. Ihnatenko (2023) noted that restrictions on the use of the simplified taxation system are defined in clauses 291.5 and 291.6 and relate, in particular, to the activities of business entities whose activities are related to the organisation and conduct of gambling, currency exchange, production and import/export of excisable goods, etc. According to S. Skrypnyk *et al.* (2023), the limited right to simplified taxation may reduce the number of taxpayers, especially in the face of uncertainty caused by the wartime legal regime. Another weakness of the simplified taxation system is the lack of a clear income threshold. As of 2024, there is no certainty as to how the income threshold will be calculated for individual entrepreneurs in the 3rd tax group. This uncertainty will complicate the planning of SME owners and may push them to decide to cease operations. In addition to these shortcomings, the current system does not provide for an automatic transition from one taxation scheme to another. The transition to the 3rd taxation group requires the owners of the enterprise to submit an application, which may take some time to be considered. Switching from one taxation group to another is also associated with the risk of delays in fulfilling tax obligations, which is also a drawback of the current accounting and taxation system.

Thus, the analysis indicates that SMEs in Ukraine operate in an environment of political and economic uncertainty, which may affect their number. To curb the negative trend, the government has proposed changes to the simplified accounting and taxation system, which are aimed at supporting the sustainable development of enterprises during the martial law regime. The main advantage of the proposed changes is the flexibility of the accounting and taxation system, which allows SMEs to choose the regime that best suits their business, strategic goals, etc. The amended simplified taxation system, however, cannot be called ideal, as its characteristic features include limited rights of application and uncertainty regarding the calculated income threshold after the termination of the martial law regime.

Peculiarities of taxation of Ukrainian farms in wartime

Small and medium-sized farms make a significant contribution to the country's economic development. They cultivated approximately 45.5% of the arable land and accounted for 46.1% of the country's gross agricultural production before the full-scale invasion of Russia. In its report, the National Institute for Strategic Studies (2024) highlighted that before the full-scale invasion, Ukraine was among the world's top five grain exporters, including wheat, which accounted for 10% of total world exports. After February 2022, the support of global partners became a key factor in the sustainable development of the sector and the maintenance of exports of key crops. As of February 2023, agrarians exported 16.1 million tonnes of wheat, 26.2 million tonnes of corn, and 5.7 million tonnes of sunflower oil. An important prerequisite for the further development of the

sector is the introduction of tax incentives for small and medium-sized farms.

Like other businesses, farms can be taxed under the general or simplified taxation system. The general taxation system is appropriate for farms with high costs, as in this case the tax is paid on profits rather than costs. The choice of the general taxation system is recommended to be made after a detailed assessment of the income that the company plans to receive. In the context of economic uncertainty, obtaining such an estimate is not an easy task, so most farms choose simplified taxation under one of the four available groups. The features of each taxation group and recommendations for their application are presented in Table 7.

Table 7. Simplified taxation system for farms

Taxation group	Features	Notes
First	Income – up to 1,118,900.00 UAH Pays 268.40 UAH of single tax and 474,000 UAH of unified social contribution	Farms with land area not exceeding 2 hectares
Second	Income – up to 5,587,80.00 UAH 1,340.00 UAH(20% of the minimum wage) of single tax and 1,474.00 UAH of unified social contribution	Farms employing up to 10 employees
Third	Income – up to 7,818,900.00 UAH VAT payers: USC – 22% of the minimum wage; single tax – 3% of income. Non-VAT payers: USC – 22% of the minimum wage; single tax – 2% of income (after the termination of the legal regime of wartime - 5%)	Suitable for farms of any size and number of employees
Fourth	No income limit Tax is calculated based on the area of land used for agricultural activities	The taxation group is recommended for farms producing marketable agricultural products. The advantages are exemption from income tax, land tax and rent for water use

Source: compiled by the authors based on D.S. Klapoushchak & Y.M. Pavliuchenko (2024), A. Minkovska *et al.* (2024)

The table above shows that the simplified taxation system offers farm owners a number of benefits that contribute to the sustainable development of this sector of the economy. The scope of these benefits largely depends on the size of the farm, the number of employees and the type of activity. These benefits include, in particular, the abolition of the need to pay a single social contribution for mobilised employees. Farm owners are also exempted from liability for late submission of financial statements and, in some cases, for late payment of taxes. Thus, farms enjoy the same accounting and taxation benefits as businesses in other segments of the economy.

There are, however, some unique privileges that have been introduced to help the agricultural sector develop in times of economic uncertainty. These benefits were approved in the Law of Ukraine No 3050-IX (2024). This draft law exempts from land payments, minimum tax liability and the single tax the farms located in the territories where military operations are or have been conducted or in the temporarily occupied territories. Land that has been contaminated by the use of explosives or is undergoing conservation is also exempt from these taxes. The approval of the draft law is an important step towards the recovery and sustainable development of the sector after the end of hostilities and the legal regime of martial law. Small and medium-sized farmers, who are exempt from paying taxes for land that is not used, have the opportunity for long-term planning, which increases the likelihood of their readiness for sustainable development of the sector.

Opportunities to reduce the tax burden and facilitate the recovery and sustainable development of SMEs in times of economic uncertainty

Based on the analysis and using the farming segment as a case study, we can offer recommendations for reducing the tax burden in the face of economic uncertainty. Such recommendations include, in particular, assistance in

choosing the optimal type of business activity, which affects the peculiarities of accounting and taxation. Using the example of farms, the author shows that the choice of the type of activity is a key point that determines a number of strategic decisions. V.V. Ratynskyi (2021) illustrated this statement with the example of other types of activities, emphasising that when planning strategic decisions, entrepreneurs need expert advice on the existing types of accounting and taxation, their features and situations in which they can be applied. For example, choosing retail or car service helps to reduce the fiscal burden by minimising the tax component, while choosing certain types of activities in the field of production or social services can reduce the burden by minimising contributions to non-budgetary funds if the simplified taxation system is chosen. Advice on choosing a type of activity can be obtained through expert advice, searching for information on specialised platforms and other sources. Cooperation with industry experts is also a source of information on government initiatives aimed at supporting and developing certain types of business activities.

It is also important to choose an option for organising an accounting service that takes into account the specifics and meets the needs of an individual company. The simplified system, which is the most common among SMEs, provides opportunities for independent accounting, thus providing for certain economic benefits. If the company's management chooses accounting services for record keeping, it is advisable to consider outsourcing, thus hiring a specialist. This staffing solution involves minimal financial costs and the ability to choose the most qualified and efficient candidate to perform financial accounting operations and timely payment of taxes.

Companies that have decided on the tax regime are recommended to conduct a systematic analysis of their business activities and financial implications of accounting. The purpose of such an analysis is to determine whether the chosen taxation system is consistent with the strategic goals of the company and whether it is possible to legally reduce the company's tax liabilities. Such methods include the following: applying a depreciation bonus to obtain a free deferral of corporate income tax; establishing a production method of depreciation on fixed assets, which can be calculated by reference to the total volume of output produced with their use; and replacing a sale and purchase agreement with a lease agreement in order to qualify for a 3x multiplier to the depreciation rate and lease payments.

Thus, there are various ways to facilitate accounting and minimise the tax burden, all of which are designed to promote the sustainable development of SMEs. During the wartime legal regime, additional opportunities were offered to ensure the survival and competitiveness of enterprises. Based on the case of farms, strategies for efficient accounting and taxation are proposed to reduce the fiscal burden on SMEs in times of economic uncertainty.

DISCUSSION

The paper proves that fiscal policy and any changes in it influence the strategic decisions of individual enterprises or certain segments of the economy. Z. Qi *et al*. (2023), in particular, confirmed this statement by surveying 100 respondents from the United Kingdom, a highly developed country with an income of GBP 965.15 billion in 2022. Based on the data obtained, the researchers developed a conceptual model of the impact of government tax policy on the development of its individual segments. The model details the relationship between changes in government tax policy and the volume of investment, economic growth and individual investment decisions. Thus, understanding the fiscal policy of the state is a prerequisite for conducting effective business activities.

X. Zhang *et al*. (2024) conducted a financial analysis of Chinese enterprises and concluded that fiscal subsidies and tax incentives increase the productivity of enterprises. The effect of fiscal subsidies and tax incentives also depends on the type of administrative regulation, as the largest effect of fiscal subsidies was observed in municipalities, and tax incentives in prefectures. Thus, it can be argued that government initiatives on accounting and taxation have an impact on strategic planning and further operation of enterprises.

The research by A.S. Atichasari & A. Marfu (2023) analysed the impact of government tax

policy and strategic decisions, including investment decisions, at the level of micro, small and medium-sized enterprises. The study was conducted among respondents representing micro, small and medium-sized enterprises in Tangerang, Indonesia. Based on the data obtained, the researchers concluded that a favourable tax policy has a positive impact on investment decisions aimed at developing micro, small and medium-sized businesses. They recommended that companies use the benefits of state tax policy to stimulate their own growth and maintain competitiveness. Thus, the cited studies emphasise the importance of government policy aimed at simplifying accounting and reducing the tax burden as a factor in the growth and sustainable development of small and medium-sized enterprises.

The conclusions on simplifying the accounting system and reducing the tax burden as a factor of enterprise sustainability in crisis conditions were also confirmed in previous studies, in particular, by R. Koch *et al*. (2023). Having analysed stock market returns for 2,729 companies in 24 countries, the researchers concluded that tax incentives have a positive impact on the rate of recovery of stock prices during the economic crisis. The researchers found that compensation for losses, including through tax relief, slows down the decline and facilitates the timely recovery of share prices during crisis events, including the global economic crisis of 2008. Conclusions were also drawn about the relationship between the profitability of the enterprise before the crisis and the level of taxation in a particular country and the speed of recovery of profitability. From the point of view of the presented work, the conclusion of R. Koch *et al*. that faster recovery and further sustainable development are more evident in countries with high taxation. This finding confirms the idea that the state has certain fiscal instruments that can be used to promote SME development in times of economic uncertainty.

The importance of government fiscal policy for the effective development of enterprises was also highlighted by O.K. Tiony & Y. Yin (2023), who used vector autoregression to analyse the relationship between fiscal policy and strategic decision-making by Kenyan businesses and concluded that it has an impact on the further recovery of economic sectors. Based on macroeconomic indicators from the International Monetary Fund (IMF) and World Bank databases, the researchers conducted a comparative analysis of countries in terms of the general tax rate and contributions, labour tax and other types of tax. The comparative analysis resulted in conclusions regarding the preservation of the progressive nature of the tax system and the simultaneous increase in social justice, the need to move from consumption taxation to income taxation and further differentiation of tax policy, the prospects for using a progressive tax scale, the prerequisites for taxing interest, dividends or capital gains, and the reform of the income tax with a differentiated approach. Thus, the previous studies provide an understanding of the impact of changes in the accounting and taxation system as a factor in the recovery of economic activity of enterprises in the crisis.

The presented recommendations for SMEs to adapt to the changed economic reality have also been confirmed in previous studies, in particular, by L. Judijanto *et al*. (2025). After analysing the tax context of different countries, the researchers concluded that the effect of accounting and taxation reform on the functioning of small and medium-sized enterprises is not unambiguous. On the one hand, transformation processes that prioritise transparency, simplicity and clear guidelines simplify the reporting and taxation process and therefore resonate with the management of small and medium-sized enterprises. On the other hand, complex and confusing reforms may encourage some SMEs to cease operations, especially if they do not have the appropriate technological and other tools to implement these changes. Thus, there is a correspondence between the findings of L. Judijanto *et al*. and the recommendation presented in this paper to use different communication channels to inform SME owners about changes in the accounting and taxation system and strategies for bringing their business activities in line with these changes. It is also important to present a list of state tax strategies aimed at sustainable development of SMEs. These strategies include, in particular, tax

subsidies and discounts, information support for SMEs, and a multifaceted approach aimed at providing equal opportunities for all business entities, regardless of their size and degree of technological equipment.

The recommendations to provide SMEs with more freedom in choosing a taxation system and flexibility in accounting practices were also confirmed by C. Li (2024), who studied the features of sustainable development of Chinese SMEs. According to the expert, the flexibility of small and medium-sized enterprises in the areas of accounting and taxation allows them to compensate for the limitations of the scale of their activities, financial and other resources. A similar opinion was found in the article by L. Verbivska *et al*. (2023), who analysed the impact of the transition to the simplified taxation system in the context of Ukrainian SMEs. The authors of the study pointed out that taxation strategies successfully used in European countries can be adapted in the context of Ukrainian SMEs for their sustainable development.

Based on previous research, it can be argued that legislative changes aimed at simplifying accounting and reducing tax burdens contribute to the recovery and sustainable development of enterprises that feel more confident in making investment and other strategic decisions. The link between government tax policy and the functioning of the business segment indicates the potential danger of the changes to the tax legislation of Ukraine as of 1 August 2023 from the point of view of sustainable development of SMEs. In the face of economic, political and social instability, businesses need more support from the state, including through a reduction in the tax burden, which facilitates long-term strategic planning.

CONCLUSIONS

Since 2019, Ukraine has seen a tendency towards a decline in the number of SMEs, which are the main driver of economic development and a key employer. The trend has been exacerbated by the full-scale invasion of Ukraine by the Russian Federation, when about half of SMEs were forced to cease to exist and another quarter were relocated to other parts of the country or abroad. Given the importance of SMEs as a major source of income and a driver of sustainable development, the government has proposed a number of initiatives aimed at simplifying accounting and reducing the tax burden on small and medium-sized enterprises. These simplifications were proposed in the Law of Ukraine No. 2173-IX (2022). Most of the benefits provided by this law, however, were cancelled in the version of this law dated 1 August 2023. As of 2024, the mandatory unified social tax was reintroduced, the single tax for companies in the first and second tax groups was increased from 2% to 5%, and the moratorium on fiscal audits was partially lifted. The new version of the law provides for easing of accounting and taxation requirements for SMEs whose tax address is located in the territory of hostilities or potential hostilities and in the temporarily occupied territories. Additional support measures have also been developed for certain sectors of the economy, including farms, which are a key component of the gross domestic product. In addition to the benefits available to SMEs from other sectors, small and medium-sized farms are exempt from paying taxes on certain resources, such as water, and land that cannot be used due to hostilities, pollution, etc. Thus, public authorities demonstrate flexibility in simplifying accounting, reducing the tax burden and creating favourable conditions for sustainable development of SMEs despite the changed reality. The actions taken can be considered effective, as 76% of SMEs declare their readiness to expand their activities despite the challenges of the times.

The proposed changes, however, have a number of limitations that should be taken into account in the strategic planning of SMEs. Potential disadvantages include the limited eligibility of businesses to apply the simplified taxation system, the lack of certainty regarding the calculated income threshold for businesses in the third taxation group after the termination of the martial law regime, and difficulties in switching from one taxation group to another. To overcome the limitations of the current accounting and taxation system for SMEs, the following recommendations were offered: seeking assistance in choosing a type of activity to reduce the fiscal burden through the benefits

of a separate taxation group, effective organisation of the accounting department and continuous analysis of business activities to identify and optimise the financial impact of accounting. The recommendations can be applied to ensure the competitiveness of SMEs and support their sustainable development in the changed economic reality. Prospects for further research may include studying the dynamics of SMEs' recovery after the changes in tax legislation as of 1 August 2023 and the factors that affect the adaptation of enterprises to the changed requirements for accounting and taxation.

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Оксана Перчук
Кандидат економічних наук, доцент
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0000-0002-6484-7011
Олена Йосипенко
Викладач
Університет Григорія Сковороди в Переяславі
08401, вул. Сухомлинського, 30, м. Переяслав, Україна
https://orcid.org/0009-0008-3537-3073

Аналіз впливу податкових ставок та пільг на бухгалтерський облік малих і середніх підприємств України: виклики та можливості

Анотація. Метою проведеного дослідження було проаналізувати вплив податкових ставок та пільг на бухгалтерський облік малих та середніх підприємств з точки зору існуючих викликів та можливостей. Були використані інструменти SWOT-аналізу, PESTEL-аналізу та кейсу малих та середніх фермерських господарств, які є одним із ключових джерел національного внутрішнього валового продукту. Під час аналізу була виявлена тенденція до зниження кількості малих та середніх підприємств, які становлять понад 99 % всіх підприємств країни та працевлаштовують 81,5 % від всього зайнятого населення. Починаючи із лютого 2022 року, біля половини малих та середніх підприємств припинили свою діяльність і ще чверть були переміщені в інші частини країни або закордон. Тимчасове зменшення податкового навантаження на такі підприємства для сприяння їхньому сталому розвитку в перший рік повномасштабного вторгнення мало позитивний ефект. Однак повернення у 2023 році довоєнних податкових норм суттєво погіршило їх економічний стан і стало перешкодою для стабільного розвитку. Станом на 2024 рік, більшість малих та середніх підприємств використовувало спрощену систему обліку та оподаткування, яка, проте, має недоліки, зокрема, обмежене право на застосування режиму спрощеної системи оподаткування та відсутність визначеності щодо розрахування порогу доходу для підприємств третьої групи після припинення дії правового режиму воєнного стану. Незважаючи на зазначені недоліки, система має позитивний вплив на діяльність малих та середніх підприємств, 76 % з яких декларують готовність до подальшого росту. Для максимізації переваг зміненої системи обліку та оподаткування підприємствам були запропоновані рекомендації щодо пошуку допомоги у виборі виду діяльності для зменшення фіскального навантаження, реорганізації бухгалтерської служби через аутсорсинг та постійного аналізу господарської діяльності для виявлення та оптимізації наслідків ведення бухгалтерського обліку

Ключові слова: фіскальна політика; фіскальне навантаження; система звітності; сталий розвиток; реформа

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Vira Butenko*
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0001-8814-9392

Tetiana Mirzoieva
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-0034-6138

Nataliia Shevchenko
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000000185061782

Viktoriia Shevliakova
Forensic Expert
The Ukrainian Scientific and Research Institute of Special Equipment and Forensic Expertise of the Security Service of Ukraine
03113, 3 Vasylenko Str., Kyiv, Ukraine
https://orcid.org/0009-0001-6452-9814

Andrii Lazutin
PhD Student
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0009-0005-0687-3771

Functioning of the grain market under global challenges: Theoretical and applied aspects

Abstract. The study aimed to analyse structural changes and influencing factors affecting the dynamics of agricultural markets to develop well-grounded forecasts for their progression. Methods employed included economic and statistical analysis, regression modelling, factor and correlation analysis, as well as forecasting using machine learning models. The article presented

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*Corresponding author

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a comprehensive assessment of the state of the grain market in Ukraine based on data for 2024. The research focused on the analysis of production volumes, export structure, and domestic consumption of grain crops, including wheat, maize, barley, rye, oats, and others. In 2024, Ukraine's total grain harvest amounted to 54.2 million tonnes, of which 35.4 million tonnes – over 65% of the total – were exported. The main export crops remained maize (21.7 million tonnes) and wheat (11.9 million tonnes). In the consumption structure, the largest shares were allocated to feed purposes (11.7 million tonnes), food needs (5.1 million tonnes), and technical use, including seed (2.0 million tonnes). The export geography was also analysed, with particular attention to the concentration of shipments to China, Spain, Egypt, Turkey and Indonesia, which together accounted for over 56% of total exports. Special attention was given to infrastructure constraints (including a 3.8% reduction in storage capacity), transport logistics (66% by seaport, 29% by rail), and price dynamics for key crops. Average prices were recorded at 232 USD/tonne for wheat, 187 USD/tonne for maize, and 198 USD/tonne for barley. It was concluded that the increase in production and consumption is accompanied by structural changes, a growing role of technology, rising costs, and the need for an adaptive policy framework. Ukraine has the potential to maintain a 9%-10% share of global maize exports, provided infrastructure development continues and logistics are stabilised. The findings of this study may be applied to the development of agricultural policy, the optimisation of export logistics, and the formation of economic strategies in the grain production sector

Keywords: food security; agricultural policy; export potential; climate risks; logistical challenges

INTRODUCTION

The relevance of this study stems from the crucial role of the grain market in ensuring food security, driving economic growth, and supporting the export potential of agricultural countries. In the context of global demand, climate change, and logistical challenges, grain remains a strategic resource. Ukraine is among the key countries significantly shaping global trends in the production and export of grain crops. This underscores the need for a systematic analysis of production, consumption, and the influence of economic factors within the context of globalisation. The core issue addressed by this research lies in the lack of a comprehensive approach to studying the grain market, taking into account international characteristics, macroeconomic shifts, agricultural transformation, and climate-related risks. Existing data are often fragmented, access to forecasting models remains limited, and there is a need to align information on production, consumption, and pricing.

Researchers have repeatedly addressed the challenges of the grain market's functioning under conditions of economic instability. For instance, the study by V. Boyko (2022) highlights the transformation of Ukraine's agricultural market under the impact of military conflict and disruptions to supply chains. According to other researchers, the structure of agricultural production in Ukraine has required deeper institutional reforms. N.M. Rudik (2021), for instance, identified macroeconomic barriers to the development of agricultural cooperatives, which directly affected the competitiveness of the grain market. Within the scope of comparative analysis, it is also worth highlighting the findings of N.V. Brailov (2024), who examined the export positions of grain crops on the global market. The study demonstrated that in recent years, the geography of Ukraine's key grain buyers has shifted, accompanied by changes in the volume and structure of exports due to fluctuations in global prices.

In the international academic context, the technical dimension of agricultural economics is developing actively. S.B. Jones *et al.* (2022) conducted a fundamental study on dielectric methods for measuring grain moisture content, which has practical significance for the storage and transport of agricultural products. Of particular note in the field of climate impact on food systems are the findings of A. Javadi *et al.* (2023) analysed the economic consequences of climate change for food security in Iran using a computable general equilibrium (CGE) model. In the context of the biological adaptation of

grain crops to climate stress, the study by B. Tadić & R. Melnik (2021) is of particular relevance. It explores self-organised critical dynamics as a key to understanding the fundamental features of complexity in physical, biological, and social networks. The authors demonstrated that the self-organisation of critical systems can be applied to enhance the resilience of agricultural ecosystems – specifically by improving plant root systems, which support more efficient absorption of water and nutrients under climatic anomalies, thereby directly contributing to production stability.

In economic discourse, increasing attention has been devoted to the theoretical grounding of effective demand as a factor shaping production volumes. In this regard, the study of P. Garegnani (2024) is significant, offering an analysis of two approaches to the formation of effective demand, based on surplus theory and intersectoral distribution. At the same time, some researchers have emphasised the financial dimension of economic transformation. Notably, L. Daumas (2024) conducted an in-depth analysis of risks associated with asset devaluation during the transition to a low-carbon development model. In the field of agricultural research, the issue of crop resilience to disease has also attracted considerable attention. The study by F. Laidig *et al.* (2021) examined advances in the breeding of winter wheat varieties with improved resistance, which helps reduce yield losses under natural infection conditions. The researchers stressed that even in traditional agroclimatic zones, the importance of genetic crop protection is increasing.

Amid climate change, growing attention has been directed towards the breeding of new crop varieties capable of withstanding extreme growing conditions. P. Langridge *et al.* (2021) argued for a strategic shift in plant breeding towards climate-resilient crops as a critical resource for food security. Their study emphasised that agricultural adaptation to climate change should begin with the scientific enhancement of seed stock. The historical and economic context of monetary policy was also explored in the research of J.S. Mill (2024), which examined the impact of currency regulation on the functioning of the banking system and market equilibrium. The author highlighted that currency stability had a direct influence on prices, exports, and the availability of raw materials, including grain crops. A notable example of structural demand adaptation is presented in the study by F. Rozi *et al.* (2023), which analysed food consumption patterns in Indonesia during the global food crisis. The authors demonstrated how, under external constraints, the population adjusted its dietary priorities – particularly concerning carbohydrate-rich crops – and how these shifts affected the domestic market. However, the integrated effects of climatic and economic factors on the grain market remain insufficiently studied. This includes cross-country comparisons of production and consumption structures, as well as long-term development scenarios that account for the challenges of globalisation.

This study aimed to conduct a comprehensive analysis of the structure and dynamics of the grain market in selected countries, taking into account economic, climatic, and logistical factors, and to develop forecast scenarios for its development under conditions of globalisation. The objectives of the research included identifying key trends in the transformation of the grain market, examining cross-country differences in the production and consumption of grain crops, and analysing the relationship between economic conditions, agricultural policy, and structural shifts in the agrarian sector.

MATERIALS AND METHODS

The scope of the study covered data for the year 2024, with particular attention given to the final stage of the 2022-2024 period, which was marked by heightened volatility due to global economic and climate-related changes. This timeframe allowed for the identification of short-term trends and cyclical fluctuations in grain production, consumption, and pricing. The methodological framework combined economic and statistical techniques with machine learning methods, including k-means and hierarchical clustering, regression analysis, and spatial analysis using open-source data. The main analytical tools included Python (with Pandas, Scikit-learn, and Matplotlib libraries), Excel, QGIS, and satellite imagery from Copernicus Open Data Hub and NASA Earth Data.

The study analysed the production, distribution, and consumption volumes of key grain crops, namely wheat, maize, and barley, as well as a group of other cereals including rye, oats, and sorghum. These crops were selected due to their central role in ensuring food and feed security, their economic significance for domestic markets and exports, and their high sensitivity to climatic and logistical changes, which makes them key indicators of the stability of the agricultural sector. Furthermore, the production, trade, and consumption data for these specific crops are well-documented in both national and international statistical sources – in particular, in databases such as FAOSTAT (n.d.), USDA (n.d.), and Eurostat (2024) – enabling objective cross-country comparisons and the development of reliable forecasts.

The study focused on a selection of countries: Ukraine, China, the USA, India, Brazil, Germany, France, Poland, Italy, and Spain. These countries were chosen for their strategic roles in the global grain market. The USA, China, and India are global leaders in terms of both production and consumption of cereals. Brazil is actively expanding its export capacity and employing advanced agrotechnologies. The European Union countries – notably Germany, France, Poland, Italy, and Spain – shape a common agricultural policy and demonstrate stable internal consumption structures. Ukraine is a key regional exporter with significant production capacity and high vulnerability to external economic conditions and logistical factors. The inclusion of these countries enabled a comprehensive analysis of the grain market at global, regional, and national levels. To analyse the structure of the grain market in Ukraine, data were sourced from the State Statistics Service of Ukraine (n.d.), agricultural analytical platforms (APK-Inform, n.d.; Latifundist, 2024), and satellite monitoring data (Sentinel-2). Factor analysis was employed to identify the key components of the market: domestic consumption, exports, and processing. Principal component analysis was used to determine the respective shares of wheat, maize, and barley in overall production and supply volumes.

To assess the influence of the macroeconomic environment on Ukraine's grain market, data from the National Bank of Ukraine (n.d.) and the International Monetary Fund (2024) were utilised. The analysis accounted for variables such as inflation rate, exchange rate, logistics costs, energy prices, government support, and the cost of fertilisers and fuel. Multiple regression was used to determine the impact of each factor on production volume and the cost of grain. Based on FAOSTAT data (n.d.), figures on grain production and consumption (in million tonnes) were collected for the selected countries. The data were normalised and aggregated by crop type. To identify trends, methods such as moving averages, linear regression, and decision trees were applied. Countries were also classified according to market type: import-dependent, self-sufficient, or export-oriented.

The grain market forecast was conducted for the following countries: China, the USA, India, Brazil, Germany, France, Poland, Italy, Spain, and Ukraine. The forecast period covered the years 2025 to 2028, aligning with the research findings that present expected figures for production, consumption, and average prices of wheat and barley in the specified countries for each year. Both machine learning and econometric models were used to forecast grain market development. Machine learning models, such as Decision Tree and Random Forest algorithms, were applied in predicting fuel costs for grain transportation (Kotenko, 2022). Econometric models, such as AGMEMOD (United Nations, 2024), were used to simulate agricultural markets, including projections for the rye market in Ukraine (Dibrova *et al*., 2024). The data sources also included climate scenarios (Hersbach *et al*., 2023) and price forecasts (World Bank Open Data, n.d.). To forecast wheat and barley prices while accounting for geopolitical risks and logistical barriers, time series methods such as SARIMA and GJR-GARCH-MIDAS models were employed (Dai *et al*., 2024). These approaches made it possible to integrate economic and political factors into the forecasting process.

Logistics indicators and support measures for the agricultural sector were analysed in detail to assess the impact of military actions on Ukraine's agricultural sector. The primary sources for this analysis included official statistics from the Ministry of Agrarian Policy and Food

of Ukraine (n.d.), Pro-Consulting (2024), and information from the Ukrainian State Fund (n.d.) on the implementation of government support programmes for agricultural producers. These materials enabled a comprehensive assessment of changes in logistics frameworks, the effectiveness of state compensation mechanisms (Kozlovskyi *et al*., 2024), and the actual influence of external factors on the economic stability of Ukraine's agricultural sector.

RESULTS

The total volume of grain production in Ukraine in 2024 amounted to 54.2 million tonnes. This figure reflects the significant role of the agricultural sector in meeting both domestic and external demand for grain crops. Compared to previous years, a decline was observed: 58.6 million tonnes were harvested in 2023, and 65.0 million tonnes in 2022. This downward trend resulted from a combination of factors, including a reduction in sown areas, unfavourable weather conditions in certain regions, limited access to resources due to military operations, and rising production costs. Grain cultivation in 2024 included traditional crops such as maize, wheat and barley, as well as smaller-scale crops like rye, oats, sorghum and others (State Statistics Service of Ukraine, n.d.). The production structure indicated a continued specialisation of the agricultural sector in commercial grain production, which remained a key focus of national agricultural policy.

In 2024, grain exports remained the dominant component of the Ukrainian market. A total of 35.4 million tonnes were exported, accounting for over 65% of total production. By comparison, 38.2 million tonnes were exported in 2023 and 50.5 million tonnes in 2022. This downward trend was driven by a decline in production, logistical difficulties – particularly in the Black Sea region – and the limited operation of seaports. Despite these challenges, the export share within the market structure remained substantial, highlighting the grain sector's sustained export orientation. A total of 35.4 million tonnes were exported, accounting for over 65% of total production. This indicated a high export orientation of the grain market. The largest share of exports was maize, totalling 21.7 million tonnes, or more than 61% of all grain exports. Wheat followed with 11.9 million tonnes, representing 33.6% of total exports. Barley accounted for 1.5 million tonnes, while other grains – including rye, oats and sorghum – amounted to 0.3 million tonnes. This distribution underscored the strong concentration of exports in two key crops – maize and wheat – which were in the highest demand among international partners (Ministry of Agrarian Policy and Food of Ukraine, n.d.).

The geographical structure of grain exports in 2024 was marked by a high degree of concentration. The top five importing countries – China, Spain, Egypt, Turkey, and Indonesia – accounted for over 56% of total exports. In 2022, the largest importers were China (7.1 million tonnes), Egypt (4.2 million tonnes), Spain (3.8 million tonnes), Saudi Arabia (3.2 million tonnes), and Pakistan (2.6 million tonnes). The structure shifted slightly in 2023, with China (6.9 million tonnes), Spain (4.1 million tonnes), and Egypt (3.5 million tonnes) remaining the leading destinations, while Turkey (2.9 million tonnes) and Indonesia (2.5 million tonnes) replaced Saudi Arabia in the top five. This trend continued into 2024, with China importing 6.4 million tonnes, Spain 4.3 million tonnes, Egypt 3.8 million tonnes, Turkey 3.0 million tonnes, and Indonesia 2.7 million tonnes. These figures reflect the stability of Ukraine's key external trading partners and a noticeable shift in export focus from Middle Eastern markets to countries in Asia and Southern Europe. This reorientation was influenced by both logistical and political factors (Elevatorist, 2024a).

Domestic grain consumption in Ukraine in 2024 amounted to 18.8 million tonnes, representing approximately one-third of total grain production. By comparison, domestic consumption reached 19.4 million tonnes in 2023 and 20.1 million tonnes in 2022. This gradual downward trend was driven by both a decline in overall production volumes and reduced activity in certain sectors of the food processing industry and livestock farming. In 2024, the largest portion of domestic grain use – 11.7 million tonnes – was allocated for animal feed, highlighting the vital role of grain in supporting the livestock sector. In 2023 and 2022, these figures were 12.2 million tonnes and 13.0 million tonnes, respectively. Grain allocated for food purposes in 2024 totalled

5.1 million tonnes, comparable to the 2023 figure of 5.2 million tonnes but slightly lower than the 5.4 million tonnes recorded in 2022. The remainder – approximately 2.0 million tonnes each year – was used for seed, technical needs, and losses.

This distribution confirmed a stable structure of domestic consumption, characterised by the dominance of feed use and a gradual decline in volumes in line with the overall reduction in production. The grain processing industry comprised approximately 1,180 enterprises engaged in both primary and advanced processing. The sector was largely made up of small and medium-sized producers operating mainly at the regional level. Between 2022 and 2024, the ratio of exports to domestic sales of processed grain products remained relatively stable: around 63% was exported, while 37% was used on the domestic market. This indicated a high dependence of the processing sector on external demand, particularly for flour, groats, compound feed, and other grain-based products (USDA, n.d.). The grain storage infrastructure included around 510 facilities with a combined capacity of 38.5 million tonnes. Despite the relatively high figures, the system remained under pressure, as some storage facilities were damaged by hostilities – especially in the southern and eastern regions. A 3.8% reduction in available capacity placed additional strain on operational facilities, forcing producers to accelerate the sale of grain or seek alternative storage arrangements (Elevatorist, 2024b).

Logistics played a crucial role in supporting grain exports. Maritime ports accounted for 66% of grain shipments. However, security risks in the Black Sea region prompted exporters to make greater use of rail corridors to EU countries, which handled 29% of export volumes. Road transport remained a supplementary channel, accounting for approximately 5%, and was primarily used in border regions or for short-haul routes. Price conditions remained stable. The average export price for wheat was 232 USD per tonne, maize sold for 187 USD, and barley for 198 USD (UkrAgroConsult, n.d.). These price levels enabled the agricultural sector to secure foreign currency revenues and maintain the profitability of grain cultivation. Prices were shaped by global market quotations, demand from key importers, transportation costs, and competition from other major exporters (Table 1).

Table 1. Structure of the Ukrainian grain market (2022-2024)

Indicator	Unit of measurement	2022	2023	2024	Notes
Total grain production	million tonnes	65.0	58.6	54.2	Decline compared to 2022 due to adverse weather conditions and reduced sown areas
Grain exports (total)	million tonnes	50.5	38.2	35.4	65.3% of production
Wheat	million tonnes	16.4	13.2	11.9	33.6% of exports
Maize	million tonnes	30.0	22.3	21.7	61.3% of exports
Barley	million tonnes	2.6	1.7	1.5	4.2% of exports
Other (rye, oats, sorghum, etc.)	million tonnes	0.5	0.4	0.3	~0.9% of exports
Main importing countries	–	–			Share of total exports
China	million tonnes	7.1	6.9	6.4	18.1%
Spain	million tonnes	3.8	4.1	4.3	12.1%
Egypt	million tonnes	4.2	3.5	3.8	10.7%
Turkey	million tonnes	2.4	2.9	3.0	8.5%
Indonesia	million tonnes	2.1	2.5	2.7	7.6%
Domestic consumption (total)	million tonnes	20.1	19.4	18.8	34.7% of production
For animal feed	million tonnes	13.0	12.2	11.7	62% of domestic consumption
For food purposes	million tonnes	5.4	5.2	5.1	27%
For seed, losses, and technical needs	million tonnes	1.7	2.0	2.0	11%
Processing industry	–	–			–
Number of enterprises	units	1,175.0	1,180.0	1,180.0	Mainly flour, groats, and pasta production

Table 1, Continued

Indicator	Unit of measurement	2022	2023	2024	Notes
Share of output exported	%	63.0	63.0	63.0	Remaining share is used domestically
Storage infrastructure	–	–			
Number of grain storage facilities	units	525.0	515.0	510.0	Some were damaged due to hostilities
Total storage capacity	million tonnes	40.0	39.5	38.5	Decline of 3.8% due to capacity losses
Average grain selling prices	USD/tonne	–			Influenced by global market conditions
Wheat	USD/tonne	245.0	238.0	232.0	Annual average
Maize	USD/tonne	198.0	192.0	187.0	Annual average
Barley	USD/tonne	210.0	204.0	198.0	Annual average
Main export logistics routes	–	–			Share of shipments
Seaports (Odesa, Chornomorsk, etc.)	%	72.0	69.0	66.0	Decrease due to risks in the Black Sea region
Rail corridors to the EU	%	24.0	27.0	29.0	Increased role of land routes
Road transport	%	4.0	4.0	5.0	Used mainly for border deliveries

Source: developed by the authors based on USDA (n.d.)

In summary, the structure of Ukraine's grain market in 2024 was characterised by a high reliance on exports, relative stability in domestic consumption, and the growing significance of the processing sector. Logistical challenges, infrastructure constraints, and price fluctuations shaped current market dynamics, while sustained international demand continued to offer potential for further development. One of the key economic factors in 2024 was the cost of grain production, which rose on average by 12.4% compared with the beginning of the year. In 2023, the increase was 9.7%, and in 2022 – 7.5%, indicating a general upward trend in production costs. The main expenditure items included mineral fertilisers, fuel, seeds, crop protection products, wages, and land lease payments. The price of diesel fuel, essential for harvesting and transport, averaged 1.20 EUR per litre in 2022, 1.40 EUR per litre in 2023, and 1.50 EUR – 1.60 EUR per litre in 2024, significantly contributing to the rise in logistical costs. Additional pressure was caused by increasing freight rail tariffs: these rose by 8% in 2022, 12% in 2023, and 18% in 2024 (Agronews, 2024).

Against the backdrop of high production costs, the profitability of grain cultivation in Ukraine was heavily dependent on global market prices. The average export price of wheat stood at 245 USD per tonne in 2022, 238 USD per tonne in 2023, and 232 USD per tonne in 2024. For maize, prices declined from 198 USD per tonne in 2022 to 192 USD per tonne in 2023 and 187 USD per tonne in 2024. Barley was priced at 210 USD, 204 USD, and 198 USD per tonne, respectively. When the price-to-cost ratio was favourable, the profitability of wheat production was estimated at 10%-14% in 2022, 9%-11% in 2023, and 8%-12% in 2024. For maize, returns were 8%-10%, 7%-9%, and 6%9%, respectively, which reduced the incentive to expand the area under cultivation. Another critical factor was the exchange rate. The average rate was 29.3 UAH per USD in 2022, 36.6 UAH per USD in 2023, and 38.2 UAH per USD in 2024. This had a substantial impact on export earnings, which accounted for up to 40% of total profits in the agricultural sector. At the same time, exchange rate volatility throughout the year created uncertainty in income forecasts and affected the cost of imported inputs (Economic Pravda, 2024).

Investment activity in the grain sector remained restrained. In 2022, investment in grain production totalled approximately 18.4 billion UAH, decreasing to 16.7 billion UAH in 2023 and 15.1 billion UAH in 2024, reflecting an annual decline of 9.3%. Large agroholdings accounted for the majority of investment, while small and medium-sized farms largely limited spending to the modernisation of core machinery. Bank

lending was more accessible in 2022, with an average interest rate of 17.9%; however, this rose to 20.3% in 2023 and reached 22.5% annually in 2024. Crop insurance remained underdeveloped: only 6% of cultivated land was insured in 2022, 6.5% in 2023, and 7% in 2024, primarily through international programmes. The high cost of policies, lack of government support, and bureaucratic complexity constrained the wider adoption of this risk management tool (National Bank of Ukraine, n.d.). Inflation also had a notable impact on the agricultural sector: it stood at 20.2% in 2022, 14.8% in 2023, and 11.2% in 2024. Due to infrastructure damage, storage capacity declined by 1.2 million tonnes in 2022, by a further 1.0 million tonnes in 2023, and by another 1.5 million tonnes in 2024. This led to an increase in storage service costs by 12% in 2022, 15% in 2023, and between 14% and 18% in 2024. As a result, many farmers were forced to sell their grain immediately after harvest (Debet, n.d.)

The export logistics situation between 2022 and 2024 remained unstable. In 2022, maritime ports accounted for 72% of grain transport, decreasing to 69% in 2023 and further to 66% in 2024. Conversely, the share of rail deliveries to the EU rose from 24% in 2022 to 27% in 2023 and reached 29% in 2024. As a result of longer routes, the average freight cost increased from 18 USD per tonne in 2022 to 22 USD in 2023 and 25 USD in 2024. The average duration of the logistics cycle also rose, from 12 days in 2022 to 16 days in 2023 and 18 days in 2024 (APK-Inform, 2024). Due to changes in export routes, the average logistics cycle time increased from 12 to 18 days. These changes in export routes led to longer delivery times, adversely affecting the timely fulfilment of international trade contracts (Table 2).

Table 2. Key economic factors influencing Ukraine's grain market (2022-2024)

Economic factor	Unit of measurement	2022	2023	2024	Impact on economic indicators
Cost of wheat production	UAH/tonne	5,700.0	6,050.0	6,400	Reduced profitability compared to 2022
Cost of maize production	UAH/tonne	6,200.0	6,600.0	6,900	High dependence on fuel
Average export price of wheat	USD/tonne	245.0	238.0	232	Positive, but limited impact
Average export price of maize	UAH/USD	198.0	192.0	187	Moderate impact
Exchange rate	%	29.3	36.6	38.2	Affects export earnings
Average inflation rate	billion UAH	20.2	14.8	11.2	Reduces purchasing power
Investment in the grain sector	%	18.4	16.7	15.1	Low activity among SMEs
Agricultural sector lending rate	%	17.9	20.3	22.5	Limited access to finance
Share of insured crop area	%	6.0	6.5	7	High risks of crop loss
Increase in storage costs	%	12.0	15.0	14-18	Forced early sales
Share of railway logistics	%	24.0	27.0	29	Route changes, rising costs
Average logistics duration	days	12.0	16.0	18	Delivery delays

Source: developed by the authors based on APK-Inform (2024)

In 2024, economic factors created a challenging environment for the functioning of Ukraine's grain market. High production costs, inflation, exchange rate fluctuations, rising logistics expenses, and declining investment activity constrained development opportunities. Despite stable export demand, domestic economic conditions remained difficult and required a comprehensive approach from the government, businesses, and international partners. Global grain production in 2024 reached approximately 2,855 million tonnes, demonstrating steady growth driven by advancements in agricultural technologies, expansion of sown areas, and improvements in infrastructure across leading agricultural countries. The largest

producers remained China, India, the USA, Brazil, Argentina, and European Union countries such as Germany, France, Poland, Italy, and Spain, collectively accounting for over 70% of the world's grain output. The widespread adoption of precision farming technologies, efficient resource use, state support, and international investment played a decisive role in enhancing production efficiency. Global grain consumption reached 2,840 million tonnes, only slightly below total output. The main consumers were countries with large populations, well-developed food processing industries, and advanced livestock sectors. Grain was used for food production, animal feed, and as an industrial raw material – particularly in the manufacture of biofuels, starch, and alcohol. The rise in consumption was driven not only by demographic trends but also by structural shifts in food supply chains in developing countries (APK-Inform, 2024).

Ukraine maintained its position as one of the leading grain exporters, ensuring consistent supplies to countries in the Middle East, North Africa, Asia, and Europe. In 2024, national grain production totalled 54.2 million tonnes, with domestic consumption amounting to 18.8 million tonnes. As a result, over 65% of total production was export-oriented. The primary crops were maize, wheat, and barley, with maize leading in export volumes, while wheat was more commonly consumed on the domestic market (Latifundist, 2024). Within the structure of domestic grain consumption in Ukraine, approximately 11.7 million tonnes were used for animal feed, reflecting the central role of grain in supporting the livestock sector. A further 5.1 million tonnes were consumed by the food industry for the production of flour, cereals, bread, and pasta. The remainder was used for seed, losses, and industrial processing. Regional consumption patterns showed a higher share of grain used for food purposes in western regions, while central and southern areas focused more heavily on feed production (International Monetary Fund, 2024).

Grain production in Ukraine remained dependent on a range of variable factors. Weather conditions, fertiliser prices, fuel costs, and logistics services played a key role. Economic policy also had a significant impact, including the level of taxation, access to finance, the investment climate, and state support for agricultural producers. In 2024, investment in agriculture was insufficient to enable a full-scale renewal of machinery, modernisation of storage infrastructure, or productivity improvements in small and medium-sized farms. Despite these challenges, Ukraine's grain sector remained competitive. The country's share in the global maize market held steady at around 10%, while wheat was exported to dozens of countries with varying standards and quality requirements. Ensuring a high level of phytosanitary control, certification, and product traceability became essential to maintaining access to demanding markets, particularly in Europe (Fig. 1).

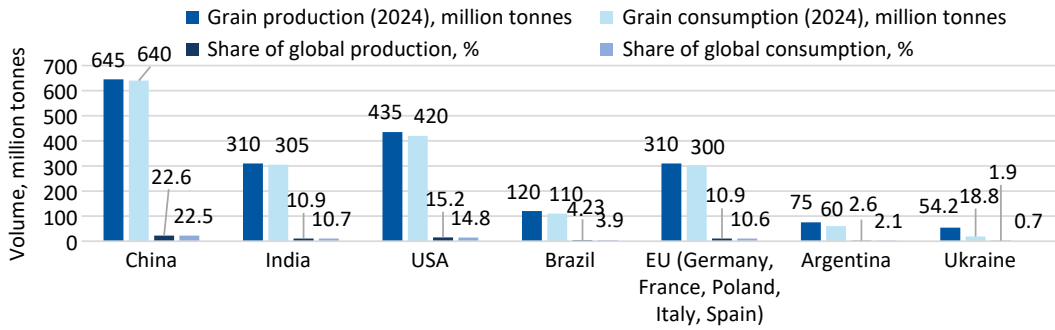

Figure 1. Grain production and consumption by country (2024)
Source: developed by the authors based on FAOSTAT (n.d.)

In summary, the structure of grain production and consumption in both the global and Ukrainian contexts remained dynamic in 2024 – flexible in the face of change and sensitive

to global economic processes. Ukraine continued to play a strategic role in ensuring international food security while also maintaining domestic food stability through a flexible consumption structure and the growing potential of its processing sector. In 2024, the grain markets in countries such as China, the USA, India, Brazil, Germany, France, Poland, Italy, Spain, and Ukraine remained dynamic, adaptable to change, and responsive to economic challenges. Ukraine played a key strategic role in securing food supplies, supporting stable domestic consumption, and developing both its export and processing capacities. From 2025 onwards, further growth in grain production is projected in these countries. Forecasted production volumes may reach 2,890 million tonnes in 2025, 2,925 million tonnes in 2026, 2,960 million tonnes in 2027, and 2,995 million tonnes in 2028. This growth is expected to be driven by the active adoption of innovations, the expansion of cultivated areas in Africa and Latin America, and the modernisation of logistics infrastructure in leading agricultural countries. Consumption is likewise expected to rise to 2,875 million tonnes in 2025, 2,910 million tonnes in 2026, 2,945 million tonnes in 2027, and 2,980 million tonnes in 2028 (Bogonos *et al*., 2024).

The greatest contribution to global grain production is expected to come from China, the USA, India, Brazil, and the European Union – particularly Germany, France, Poland, Italy and Spain. In China, production may stabilise at over 645 million tonnes, with consumption reaching up to 660 million tonnes. The USA could achieve volumes of up to 450 million tonnes, supported by the widespread adoption of precision agriculture. India, through its robust agricultural programmes, is projected to maintain production at 310-320 million tonnes. In Brazil, the development of irrigation systems and biotechnologies is likely to boost output to around 130 million tonnes. In Germany, France, Poland, Italy and Spain, total production may reach 318 million tonnes by 2028 (United Nations, 2024).

The structure of grain consumption is shifting increasingly towards feed use, particularly in China, the USA, India and Indonesia. The share of feed grain in total consumption may exceed 50% by 2028. Demand is also expected to rise in the energy sector, especially for bioethanol production in the USA, Brazil and EU countries. Price dynamics are likewise projected to follow an upward trend. The average global price of wheat is forecast to reach 248 USD/tonne in 2025, 255 USD/tonne in 2026, 262 USD/tonne in 2027 and 268 USD/tonne in 2028. Maize prices are expected to reach 193 USD/tonne, 199 USD/tonne, 203 USD/tonne and 208 USD/tonne, respectively. The main drivers of this price growth are anticipated to be logistics costs, energy markets, and geopolitical risks (World Bank Open Data, n.d.).

Between 2025 and 2028, Ukraine is expected to maintain grain production within the range of 55-60 million tonnes. The export potential of maize may reach up to 25 million tonnes annually, with key markets including China, Spain, Italy, Egypt and Indonesia. Ukraine's share in global maize exports could account for 9%-10%. At the same time, domestic processing of bioethanol and flourbased products is expected to expand (Mind, 2024). By 2028, over 60% of large agricultural enterprises in the USA, Brazil, Germany and France may adopt fully automated field management systems, significantly increasing production efficiency. In Ukraine, the level of digitalisation is projected to remain at around 25%-30%, with potential for growth supported by both state and international initiatives (Table 3).

Table 3. Forecasts for the development of the grain market under globalisation (2025-2028)

Year	Country	Production (million tonnes)	Consumption (million tonnes)	Average wheat price (USD/tonne)	Average barley price (USD/tonne)
2025	China	648	645	248	220
2026	China	652	650	255	226
2027	China	656	655	262	232
2028	China	660	660	268	238
2025	USA	438	422	248	220
2026	USA	442	425	255	226

Table 3, Continued

Year	Country	Production (million tonnes)	Consumption (million tonnes)	Average wheat price (USD/tonne)	Average barley price (USD/tonne)
2027	USA	446	428	262	232
2028	USA	450	430	268	238
2025	India	312	308	248	220
2026	India	315	311	255	226
2027	India	318	314	262	232
2028	India	320	317	268	238
2025	Brazil	122	112	248	220
2026	Brazil	125	114	255	226
2027	Brazil	128	116	262	232
2028	Brazil	130	118	268	238
2025	Germany, France, Poland, Italy, Spain	312	302	248	220
2026	Germany, France, Poland, Italy, Spain	314	304	255	226
2027	Germany, France, Poland, Italy, Spain	316	306	262	232
2028	Germany, France, Poland, Italy, Spain	318	308	268	238
2025	Ukraine	56.0	19.0	248	220
2026	Ukraine	57.0	19.5	255	226
2027	Ukraine	58.0	20.0	262	232
2028	Ukraine	60.0	20.5	268	238

Source: developed by the authors based on H. Hersbach *et al.* (2023), estimates based on GJR-GARCH-MIDAS time series modelling

Thus, between 2025 and 2028, the functioning of the grain market in countries such as China, the USA, India, Brazil, Germany, France, Poland, Italy, Spain and Ukraine is likely to be shaped by a combination of interconnected economic and structural factors. Gradual increases in production costs, fluctuations in energy prices, logistical challenges, and global inflationary trends are expected to create a complex environment for sustainable development. At the same time, technological innovations, growing demand for bioenergy feedstocks, rising feed grain consumption and the intensification of international trade will support positive market dynamics. Despite challenging domestic conditions, most countries are projected to maintain their production capacities through modernisation, supportive agricultural policies and diversification of export markets.

In 2022, grain exports through the "grain corridor" totalled 21.8 million tonnes, accounting for over 53% of total exports. This underscored the critical role of maritime transport in grain logistics, even amid wartime challenges. However, in 2023 and 2024, this figure declined steadily, falling to 11.2 million tonnes in 2023 and 9.4 million tonnes in 2024. The decline in maritime transport volumes was driven by heightened risks to shipping in the Black Sea region, as well as increased vessel idle times in ports due to stricter inspection and security procedures. In particular, the average vessel layover increased from 21 days in 2022 to 29 days in 2024. This reflected rising logistical costs and reduced efficiency of transport operations, which negatively affected the competitiveness of Ukrainian grain on international markets (Food and Agriculture..., 2024). Against the backdrop of declining maritime shipments, the share of rail transport in total grain exports increased. While in 2022 rail accounted for only 27.3% of total grain exports, by 2024 this figure had risen to 35.2%. This growth was a necessary response to the maritime blockade and security threats to sea routes. However, rail transport faced its own limitations,

including insufficient capacity and high logistical costs, which further worsened the economic performance of agricultural producers (Pro-Consulting..., 2024).

An analysis of the effectiveness of state support programmes for farmers reveals a growing number of compensation applications. In 2022, 58.2 thousand applications were submitted; this rose to 61 thousand in 2023 and reached 65.8 thousand in 2024. However, the approval rate for these applications steadily declined, from 44.6% in 2022 to just 30.5% in 2024. This trend indicates increasing bureaucratic barriers, budgetary constraints, and limited flexibility in the review and decision-making processes. As a result, despite the rising number of applications, the actual amount of compensation disbursed decreased from 3.2 billion UAH in 2023 to 2.7 billion UAH in 2024 (Ukrainian State Fund, n.d.). International support for the agricultural sector also played a significant role. In 2022, it amounted to 6.7 billion UAH, rose substantially to 12.4 billion UAH in 2023, but then declined again to 10.9 billion UAH in 2024. These fluctuations reflect the instability of external funding, partly driven by changing political conditions and a shift in donor priorities. An important social aspect of the support programmes was the growing share of smallholder farmers among compensation recipients. In 2022, small farms accounted for 61% of recipients, rising to 69% by 2024. This was a positive indicator in terms of providing social support to the most vulnerable participants in the agricultural sector, particularly those most affected by the war and economic losses (Table 4).

Table 4. Logistics and agricultural support indicators (2022-2024)

Indicator	2022	2023	2024
Grain exports via the "grain corridor", million tonnes	21.8	11.2	9.4
Share of maritime transport in total exports, %	53.1	42.8	39.5
Share of rail transport in total exports, %	27.3	31.5	35.2
Average vessel delay time in the corridor, days	21.0	27.0	29.0
Number of compensation applications, thousand	58.2	61.0	65.8
Approved applications, %	44.6	34.1	30.5
Total compensation payments, billion UAH	1.9	3.2	2.7
International support (UAH equivalent), billion	6.7	12.4	10.9
Share of smallholder farmers among recipients, %	61.0	67.0	69.0

Source: developed by the authors based on Ukrainian State Fund (n.d.), Ministry of Agrarian Policy and Food of Ukraine (n.d.)

Overall, the analysis of data from 2022 to 2024 demonstrated that Ukraine's agricultural sector suffered significant losses due to the war and logistical constraints. On the one hand, the decline in maritime exports and the growth of rail transport indicated serious structural changes in logistics. On the other hand, although state compensation programmes played an important role in supporting farmers, a range of administrative and financial challenges prevented them from fully offsetting the losses incurred. Consequently, the sector's further development requires stronger state support policies, in particular through optimising compensation procedures, stabilising international aid, and developing alternative export corridors for Ukrainian grain.

DISCUSSION

The findings indicate that the grain market remains highly dynamic in the world's leading countries, with China, the USA, India, Brazil, EU member states, and Ukraine playing particularly significant roles. Projected growth in

production, reaching up to 2,995 million tonnes by 2028, is likely to be accompanied by an almost proportional increase in consumption, reflecting stable global demand. At the same time, the share of grain used for feed is expected to continue rising, prompting structural shifts in domestic markets across many countries. Ukraine's strengthening export potential, despite logistical constraints, highlights its adaptability; however, this also underscores the need for infrastructure modernisation and sustained government support. In the EU and the USA, there is a clear trend towards increased technological integration, particularly the adoption of automated systems in large-scale agricultural enterprises. Alongside these developments, the growing impact of climate-related challenges – such as yield fluctuations and drought risk – emphasises the need for adaptive crop varieties and adjustments in agronomic practices.

In particular, J. Małecki *et al.* (2021) and T. Qiu & B. Luo (2021) focused on specific aspects of agricultural production that partially align with the findings of this study. J. Małecki *et al.* examined the functional properties of proteins in cereal products and their potential applications in modern food systems. While this approach is valuable for assessing grain quality, it does not consider the broader economic or market context addressed in the present study. By contrast, T. Qiu & B. Luo concentrated on the impact of agromechanisation in small-scale farming in China. Their conclusions highlight the importance of technological factors in improving crop yields, which partly corresponds with the findings of this research. However, in the present approach, technological advancement is viewed more broadly – not merely at the level of farming practices, but as part of the wider transformation of the agricultural sector under the influence of global climate and economic changes.

R. Anibaldi *et al.* (2021) also examined grain markets from the perspective of institutional and logistical efficiency. Their focus was on the barriers to implementing sustainable agricultural practices, particularly regarding farmer motivation and support systems. While their conclusions are important for understanding the socio-economic dimensions of the sector, the study is largely descriptive and does not include a quantitative analysis of production or consumption indicators. X. Peng *et al.* (2022) developed a multi-channel information management model for the rice supply chain. Although their approach is logistically effective, it is limited to a single crop and region, without incorporating forecasting dynamics, climate-related risks, or global pricing trends. In contrast, the present study integrates institutional, logistical, economic, and agroclimatic approaches within a unified framework of analysis and scenario modelling. A. Dibrova *et al.* (2024) explored the functioning of the rye market as a niche grain crop in the context of rising mineral fertiliser costs. Their research focused on forecasting and modelling production and price dynamics – issues highly relevant in light of global challenges such as economic instability and the agricultural sector's reliance on external resources. The authors highlighted the importance of adapting agricultural policy to changes in the fertiliser market, given its direct impact on the profitability of grain cultivation.

Researchers S.R. Tushar *et al.* (2023) addressed issues related to grain storage resilience and the circular economy in agricultural supply chains. Their study examined factors influencing the stability of grain storage – particularly moisture levels, temperature, ventilation, and their impact on food security. This presents a valuable addition to the technological dimension, which is also considered in the present analysis. However, the research by S.R. Tushar *et al.* does not explore forecasted changes in market structure or global demand dynamics. In turn, A.A. Dossa *et al.* (2022) focused on the spread of the circular economy in the wheat supply chain in the United Kingdom. While their analysis is relevant in the context of sustainable development, it remains geographically and conceptually limited. By contrast, the present study offers a more comprehensive approach – encompassing a broader range of countries and crops, and integrating economic, environmental, logistical, and forecasting components within a unified interdisciplinary framework.

Researchers T. Mukherjee *et al.* (2023) proposed approaches that enhance the overall understanding of analytical methods in the agricultural and related sectors. Their study focused on managing grain microstructure in the context

of additive manufacturing, emphasising the precision of material control. Although the research concerned metals, the principle of controlling quality parameters holds cross-sectoral relevance for agricultural production, particularly in grain storage and processing. Meanwhile, S. von Cramon-Taubadel & B.K. Goodwin (2021) conducted a comprehensive analysis of price transmission in agricultural markets, focusing on responses to global price shocks. Despite the high level of analytical depth, their study is confined to price-related factors. In contrast, the present research incorporates a broader set of variables – from agroclimatic conditions to logistical constraints and geoeconomic risks – offering a more integrated and multifaceted factor analysis.

E. Tadele & T. Hibistu (2021) examined transformational processes within national agri-food systems, with a particular focus on internal development factors. Their study explored the use of teff in Ethiopia's agricultural sector, highlighting its nutritional value, cultural significance, and stable role in consumer diets. The research demonstrated a link between local practices and systemic food security; however, it lacked macroeconomic or forward-looking analysis. Meanwhile, Y. Liu *et al.* (2023) investigated the impact of financial liberalisation on productivity growth in China's agricultural sector, employing a mechanistic model that accounted for the quality of land, labour, and capital. Despite the analytical depth of both studies, each remained limited to a single national context and did not incorporate cross-country comparisons or assessments of global trends – key elements in the present research aimed at constructing a comprehensive picture of the market up to 2028.

At the same time, S. Das *et al.* (2023) and P. Khatri *et al.* (2024) presented a multidimensional perspective on agricultural risks, focusing on the interconnections between environmental, economic and social factors. P. Khatri *et al.* examined the nature of compound risks in agricultural production, concentrating on how the simultaneous emergence of climatic, economic and political threats affects the functioning of food systems. While the study highlights the need for systemic management, it does not provide a quantitative basis or forward-looking projections. By contrast, S. Das *et al.* developed a strategic risk assessment model for grain supply chains, applying a businessoriented approach to sustainable development. Both approaches offer valuable conceptual insights but lack in-depth analysis of production volumes, consumption, price dynamics and crosscountry differences, all of which are addressed in detail in this study through a combined empirical and forecasting model.

D. Prajapati *et al.* (2022) and M. Kanan *et al.* (2023) provided important practical insights into operational improvements in the agricultural sector. D. Prajapati *et al.* proposed an approach to environmentally sustainable routing in grain e-commerce, focusing on reducing logistical costs and the ecological footprint. Despite its technical innovation, the absence of an assessment of economic or climatic changes limits the model's relevance for macro-level analysis, which was addressed in the present study. Meanwhile, M. Kanan *et al.* conducted an empirical study on statistical control systems in the food industry, emphasising the need to improve quality standards. However, their approach remained narrowly focused on production and did not consider the structural transformations of agricultural markets, which this study explored through the lens of prices, demand and forecasts up to 2028.

It is also worth noting that R. Gupta & R. Shankar (2024) focused on risks and technological solutions in the food sector. They introduced the concept of blockchain traceability as a tool to enhance transparency and trust in grain supply chains. Despite its strategic value, the study did not address macroeconomic influences, demographic shifts or climate risks, which are key elements in the present model. In turn, M. Letta *et al.* (2022) analysed market responses to weather shocks, emphasising the importance of price expectations among traders in an increasingly unstable climatic environment. While this approach partially aligns with the current findings, it lacks the systemic cross-country assessment that this study implements through structural comparison.

Attention should also be given to the research by J. Yang *et al.* (2021), which contributed to understanding the exchange and geopolitical factors shaping the grain market. The researchers conducted a comprehensive analysis of China's

agricultural futures markets, focusing on the mechanisms of exchange price formation. While the findings are significant, the study remained confined to the national financial system, without integrating factors such as international trade, climate change, or the internal structure of consumption. In contrast, A. Rose *et al.* (2023) examined the impact of military conflict on global grain export flows, particularly in the context of Ukraine. This approach holds considerable political relevance; however, the study did not include an in-depth analysis of production-consumption systems or adaptive technologies, which form the foundation of the present study's scenario-based modelling. Compared with individual studies, this research encompasses a broader geographical, economic and temporal scope, offering a deeper understanding of the transformational processes within the global agricultural system. The findings not only align with selected scientific conclusions but also enhance them through an interdisciplinary, forwardlooking analysis that holds practical value for strategic planning in the agricultural sector.

In conclusion, the results of the study demonstrate the advanced development of the grain market, particularly in Ukraine and leading global producers such as China, the USA, India, Brazil and EU countries. The projected increase in grain production by 2028 indicates stable demand for this strategic resource, while the rising share of grain used for feed is reshaping domestic market structures in many countries. Notably, Ukraine's adaptation to logistical constraints and the need to modernise infrastructure are critical for maintaining and expanding its export potential.

CONCLUSIONS

In the course of the study, a comprehensive analysis was conducted of the logistical factors affecting the functioning of Ukraine's grain market during the war and the period of geopolitical instability from 2022 to 2024. Particular attention was given to changes in the export structure, the development of processing infrastructure, and issues related to domestic consumption and state support. According to the findings, total grain production in Ukraine reached 54.2 million tonnes in 2024. This figure confirmed the significant role of the grain sector in meeting both domestic and external demand, with exports accounting for over 65% of total production. Maize constituted the largest share of grain exports, representing more than 61% of the total. The geographical structure of exports showed a high concentration in a limited number of importing countries, notably China, Spain, Egypt, Turkey and Indonesia, highlighting the strategic importance of the Asian and Mediterranean markets for Ukraine. One of the key challenges that emerged during the war was the reconfiguration of logistical routes. Due to the maritime blockade, the share of rail transport rose from 27.3% in 2022 to 35.2% in 2024. This shift was a necessary response to offset the decline in maritime exports; however, rail transport faced limitations in capacity and incurred high logistical costs. The study also focused on evaluating the effectiveness of government compensation programmes for farmers, which constituted a vital element of support for Ukraine's agricultural sector. It was found that although the number of applications for compensation increased, the approval rate declined, indicating the presence of bureaucratic barriers and budgetary constraints. The total amount of compensation disbursed in 2024 was 2.7 billion UAH, which was lower than in the previous year. Overall, the study demonstrated that Ukraine's agricultural sector continued to adapt to new conditions. Nonetheless, for sustainable development amid global economic challenges and domestic difficulties, it is essential to strengthen state support, streamline compensation procedures, and develop alternative transport routes for grain exports. A key limitation of the study is its dependence on the availability of statistical data and the lack of complete information for certain regions. Future research could focus on a more in-depth analysis of climate scenarios and the impact of innovative technologies on the efficiency of grain production.

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Віра Бутенко
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0001-8814-9392

Тетяна Мірзоєва
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-0034-6138

Наталія Шевченко
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000000185061782

Вікторія Шевлякова
Судовий експерт
Український науково-дослідний інститут спеціальної техніки та судових експертиз Служби безпеки України
03113, вул. Василенка, 3, м. Київ, Україна
https://orcid.org/0009-0001-6452-9814

Андрій Лазутін
Аспірант
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0009-0005-0687-3771

Функціонування ринку зерна в умовах глобальних викликів: теоретико-прикладні аспекти

Анотація. Метою дослідження був аналіз структурних змін і факторів впливу на динаміку аграрних ринків для формування обґрунтованих прогнозів їх розвитку. При проведенні дослідження були використані методи економіко-статистичного аналізу, регресійного моделювання, факторного та кореляційного аналізу, а також прогнозування на основі моделей машинного навчання. У статті представлено комплексну оцінку стану ринку зерна в Україні за результатами 2024 року. Дослідження зосереджено на аналізі обсягів виробництва, структури експорту та внутрішнього споживання зернових культур, включаючи пшеницю, кукурудзу, ячмінь, жито, овес та інші. Встановлено, що валовий збір зерна в Україні у 2024 році склав 54,2 млн тонн, при цьому експортовано було 35,4 млн тонн, що становило понад 65 % від виробленого. Основними експортними культурами залишались кукурудза (21,7 млн тонн) та пшениця (11,9 млн тонн). У структурі споживання найбільшу частку займали кормові цілі

(11,7 млн тонн), продовольчі потреби (5,1 млн тонн) та технічні потреби з насінням (2,0 млн тонн). Також було проаналізовано географію експорту, зокрема концентрацію поставок у Китай, Іспанію, Єгипет, Туреччину та Індонезію, на які припадало понад 56 % експорту. Окрему увагу приділено інфраструктурним обмеженням (зниження потужностей зберігання на 3,8 %), логістичним каналам перевезень (66 % – морськими портами, 29 % – залізничним транспортом), а також динаміці цін на основні культури: середні ціни склали $ 232/т для пшениці, $ 187/т для кукурудзи та $ 198/т для ячменю. Зроблено висновок, що зростання виробництва та споживання супроводжується структурними змінами, підвищенням ролі технологій, зростанням витрат і потребою в адаптаційній політиці. Україна має потенціал зберегти 9-10 % частки світового експорту кукурудзи за умов подальшого розвитку інфраструктури та стабілізації логістики. Результати дослідження можуть бути використані для розробки аграрної політики, оптимізації експортної логістики та формування економічних стратегій у сфері зернового виробництва

Ключові слова: продовольча безпека; аграрна політика; експортний потенціал; кліматичні ризики; логістичні виклики

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Valerii Bondarenko
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-5929-7158

Violeta Heraimovych*
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-4721-5100

Yuliia Havryliuk
PhD in Economic Sciences
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-0774-3494

Olena Barylovych
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-1732-3637

Alla Riabchyk
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0001-6290-3609

Marketing and logistics support for agricultural and processing enterprises

Abstract. This article aimed to examine the impact of marketing and logistics strategies on the economic performance of agricultural enterprises in Ukraine, particularly in terms of competitiveness, cost optimisation, and income growth. To achieve this, the study employed a methodology involving the analysis of the economic aspects of marketing and logistics support

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*Corresponding author

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for agricultural enterprises, using academic publications, industry reports, and practical data. Both quantitative and qualitative research methods were used to assess effectiveness, including financial performance analysis, evaluation of marketing and logistics strategies, and analysis of the impact of digital technologies on business process efficiency. The findings revealed that the integration of marketing and logistics strategies enabled agricultural enterprises to significantly reduce costs, particularly in transportation and storage. The introduction of digital platforms for inventory management and transport optimisation led to a 12%-18% reduction in expenses. In 2024, the total revenue of Ukrainian agricultural enterprises reached 2.4 trillion UAH, which is 2.6 times higher than the figure recorded in 2023. The highest revenue volumes were recorded in Vinnytsia (292.8 billion UAH), Cherkasy (265.3 billion UAH), and Poltava (216.2 billion UAH) regions. The implementation of automated transport systems reduced transportation costs by 10%-20%, while the use of Global Positioning System monitoring to optimise routes resulted in a 15% decrease in fuel expenditure. The findings confirmed that the effective use of marketing and logistics strategies has become a key factor in ensuring the competitiveness of agricultural enterprises. The integration of marketing and logistics enabled cost reduction, improved operational efficiency, and contributed to the financial resilience of enterprises in the face of global economic challenges. The introduction of digital tools and process automation proved essential for achieving high productivity and cost reduction. The practical significance of the study lies in the development of recommendations for optimising the marketing and logistics processes of agricultural enterprises, enabling reduced costs, enhanced management efficiency, and greater financial stability in a dynamic market environment

Keywords: competitiveness; innovation; inventory optimisation; transportation; demand forecasting

INTRODUCTION

Agricultural enterprises engaged in crop production, along with processing companies involved in food manufacturing, face numerous challenges. These include the need to optimise costs related to transportation, storage, and product distribution, the provision of high-quality customer service, and the efficient management of information flows. At the same time, the rapid advancement of digital technologies, the integration of modern marketing tools, and the use of innovative logistics solutions are creating new opportunities to enhance the efficiency of these processes.

In the study of marketing and logistics aspects of agricultural enterprises in international markets, scholars such as V. Danylenko *et al.* (2024) have explored the importance of effective logistics and marketing for the export activities of agribusinesses. The authors identified key issues faced by Ukrainian agricultural producers, particularly limitations in transport infrastructure, which reduce the efficiency of agricultural exports. Their research highlights the significance of integrating marketing strategies with logistics processes, as this enables agricultural enterprises to strengthen their positions in international markets. Marketing is not used effectively enough in agricultural enterprises, which restricts their market potential. O. Kuzmenko (2024) noted that marketing in this sector often focuses solely on increasing sales and maximising profits, without long-term strategic planning. She emphasised that to ensure competitive advantage, it is essential to consider producers' flexibility and their ability to respond swiftly to changing market conditions, while also embracing innovation.

Logistical constraints and cultural specificities of international markets present significant challenges for agricultural enterprises. S. Pavlyshyn & V. Melnychenko (2024) examined the marketing and logistics support for grain exports from Ukraine during martial law, focusing on changes in supply chains and the impact of military aggression on logistics costs. The authors proposed alternative routes for transporting grain, including those through the Grain Corridor. Their findings indicated increased costs and reduced transhipment volumes at ports. Marketing efforts by agricultural

enterprises in entering global markets possess specific characteristics shaped by natural and climatic conditions, seasonal production cycles, and the high level of competition internationally. V. Serov (2024) highlighted the importance of adapting products, logistics processes, and communication strategies to global market requirements. This includes product standardisation, the development of long-term contracts, and the adoption of flexible supply schemes. The results of his study demonstrated that implementing these strategies enhances the effectiveness of marketing activities.

The marketing potential of agricultural enterprises is a key factor in ensuring their competitiveness under conditions of market globalisation and growing international rivalry. Y. Korol & V. Pysmak (2024) investigated the development of marketing potential in agricultural enterprises, emphasising the importance of adopting modern tools to create competitive advantages. The authors argued that marketing activities are essential for ensuring efficient enterprise operations in the current economic climate, improving both market position and financial performance. Managing the marketing activities of Ukrainian agricultural enterprises under martial law remains a pressing task. A. Movchanyuk (2023) observed that agribusiness faces serious challenges owing to the blockade of traditional sales channels, the destruction of infrastructure, and disruptions to supply chains. The author emphasises the need for an integrated marketing management system that enables enterprises to adapt to new conditions and retain competitiveness in both domestic and foreign markets.

Digital technologies in marketing and logistics play a crucial role in optimising business processes within agricultural enterprises. O. Kyfyak *et al.* (2023) analysed the impact of digital marketing and logistics on the efficiency of business-process management in the sector. The researchers argue that integrating digital technologies reduces costs, improves product quality, and enhances competitiveness. They also found that deploying digital tools in marketing helps enterprises adapt more effectively to market changes. The optimisation of logistics solutions in agricultural management is equally critical. N. Makarenko & S. Vovchok (2020) examined strategic logistics management in agricultural enterprises, focusing on the effectiveness of logistics decisions in boosting competitiveness. Their findings indicate that implementing efficient logistics strategies can significantly lower costs while improving the distribution of agricultural products.

However, the impact of introducing advanced logistics technologies, as well as improvements in customs and certification procedures, on reducing costs and increasing transport efficiency in the agricultural sector has not been sufficiently explored. Other under-researched areas include the adaptation of marketing strategies to the dynamics of international markets, the influence of digitalisation on the functioning of agricultural enterprises, and the role of government support in developing their marketing potential during martial law. Greater attention should also be given to analysing the relationship between digital marketing tools and logistics processes in the context of ensuring the long-term stability of enterprises. This study aimed to examine the effectiveness of optimising logistics solutions to support the strategic management of agricultural enterprises. The specific objectives were to assess the impact of logistics decisions on the competitiveness of agricultural enterprises and to develop recommendations for improving logistics processes in order to enhance management efficiency under changing market conditions.

MATERIALS AND METHODS

The study had an applied economic focus and was conducted over the period 2022-2024. It covered current trends in the agricultural sector and the adaptation of enterprises to new market conditions. The analysis was based on academic publications, including studies by M. Haji Ali Beigi (2021), O.V. Kopytko (2023), and I. Shkorina (2024), which contributed to a deeper understanding of economic processes in the agricultural sector through the integration of marketing and logistics. These publications provided valuable insights into the factors influencing competitiveness and efficiency within the sector, particularly regarding how effective marketing and logistics strategies have supported the

overall economic performance of agricultural enterprises. The study examined the economic aspects of marketing and logistics support, with a focus on the impact of marketing and logistics strategies on enterprises' financial indicators. Special attention was given to the integration of marketing and logistics as a tool for enhancing economic efficiency. The effectiveness of marketing strategies was analysed in terms of income growth, cost reduction, and overall enterprise profitability. The study also explored key logistics strategies and assessed their economic viability for the agricultural sector, enabling evaluation of their impact on overall economic performance. One important aspect of the research was the use of digital platforms to optimise logistics processes in the agricultural sector. Platforms such as AgroOnline (n.d.), Uagro (n.d.), TopAgro (n.d.), AgriSync (n.d.), AirFarm (n.d.), Agrifinance (Agrifinance Online, n.d.), and Agrocontrol (Propozitsiya, 2022; Stfalcon, 2021) have significantly contributed to reducing transportation, storage, and inventory management costs. In addition, the study highlighted the implementation of Automated Transport Systems (ATS) (Vorecol, n.d.) in processing enterprises, which has enabled reductions in transportation costs, as well as improvements in productivity and order fulfilment accuracy. The role of automation in reducing manual intervention and improving logistics operations was assessed. The methodology also involved the development of recommendations for enhancing the marketing and logistics processes of agricultural enterprises. A key component of the study was the integration of marketing and logistics operations, the implementation of advanced technologies such as automation, and the use of analytical data to optimise supply chains. In addition, the strategic planning of marketing campaigns aimed at increasing demand and improving financial outcomes was analysed in detail. The application of digital tools – such as the Internet of Things (IoT), artificial intelligence (AI), and data analytics – for managing supply chains and marketing efforts was evaluated. The research employed both quantitative and qualitative methods, using data from the industry report by Opendatabot (The income of agricultural industry leaders..., 2024), including revenue figures for the largest agricultural enterprises. The methodology also included case analysis of enterprises that had successfully implemented integrated marketing and logistics strategies. Indicators such as revenue growth, cost reduction, and profitability were evaluated to determine the effectiveness of the strategies applied (Agroportal, 2024; SuperAgronom, 2024).

RESULTS

Economic aspects of marketing and logistics ensuring

Marketing and logistics support in the agricultural sector and at processing enterprises is a complex, multifaceted process that encompasses the planning, management, and integration of every element required for the efficient movement of goods from producer to final consumer. It involves not only logistics operations – transportation, storage, and handling – but also marketing strategies that promote a clear understanding of market needs, stimulate demand, and sustain an enterprise's competitiveness.

The principal objective of marketing and logistics support is to establish an effective mechanism for delivering products to consumers at minimal cost and under optimal conditions. Within the agricultural sector, rapid and safe transport is critical, as many products have limited shelf lives and require specific transport conditions. Processing enterprises must, therefore, not only create efficient supply chains for raw materials but also maintain favourable conditions for storing, handling, and delivering finished goods to the market.

Marketing and logistics support in agriculture comprises several key elements. The first is logistics management, covering the transport, storage, and handling of goods. This function organises and streamlines these processes, ensuring timely delivery to the point of sale while keeping costs low. In the agricultural sector, critical aspects include monitoring product quality during transit, utilising optimal routes, and employing modern storage technologies, such as the cold chain for fresh produce. Problems that may arise in this process include product losses due to improper storage or delays in transportation, both of which can lead to economic losses (Zutsara, 2022).

Marketing support, in turn, focuses on understanding consumer needs and preferences, as well as developing strategies for effective product promotion. In the agricultural sector, marketing involves market research, segmentation, product positioning, and the development of efficient distribution channels. As demand for agricultural products is often influenced by seasonality, it is important to adopt a strategic approach to product assortment and pricing. Marketing also includes brand development and the analysis of market trends, enabling enterprises to adapt their offerings in response to market changes and shifting consumer preferences (Naruetharadhol *et al.,* 2022).

For processing enterprises, marketing and logistics support takes on particular significance due to the need for uninterrupted raw material supply and efficient distribution of finished products. These enterprises face challenges such as intense competition, the need to meet quality standards, and packaging requirements, all of which can affect costs and profit margins. A key aspect is the coordination between raw material suppliers and processing companies to ensure optimal production capacity and minimise costs (Khedr & Rani, 2024).

Thus, marketing and logistics support in the agricultural sector and at processing enterprises is a vital component of economic strategy. It encompasses both logistics management and marketing strategies aimed at ensuring competitiveness in the marketplace. This requires careful planning and continuous monitoring of all processes to achieve maximum results with minimal costs, while also providing optimal conditions for consumers. The impact of marketing and logistics strategies on enterprises' economic performance is significant, operating through various yet complementary mechanisms. Both marketing and logistics play a crucial role in enhancing an enterprise's economic efficiency by influencing indicators such as profitability, market growth, competitiveness, and financial stability.

Marketing strategies are closely linked to a company's financial performance. Investment in marketing – particularly in advertising, branding, and corporate social responsibility (CSR) – has a direct effect on long-term financial outcomes and the enterprise's competitive position. Research has shown that marketing expenditure correlates with higher return on assets (ROA), improved market-to-book ratios, and increased investor confidence. Resource-based theory views marketing as a strategic capability that enhances a company's value by fostering customer loyalty and strengthening pricing power. Market-oriented companies typically outperform their competitors in terms of profitability and sales, particularly during periods of economic downturn. Moreover, CSR initiatives have the greatest multidimensional impact on financial performance, positively affecting eight financial indicators, including net income and shareholder value. Such initiatives enhance a company's reputation, which in turn increases its attractiveness to investors (Köylüoğlu *et al.*, 2021).

On the other hand, logistics strategies significantly influence an enterprise's economic efficiency by improving performance and introducing innovation in logistics processes. A study conducted in Guangdong Province found that a 1% increase in logistics expenditure resulted in a 0.407% rise in local Gross Domestic Product (GDP) and a 0.359% impact on neighbouring regions (Li & Chen, 2021). This highlights the fact that improving logistics networks contributes to economic growth not only at the enterprise level but also regionally. Innovations in logistics – such as digital supply chains and automated inventory systems – help reduce operational costs and increase customer value.

Innovations introduced into logistics processes – particularly within digital supply chains – greatly enhance companies' adaptability and reduce costs. In addition, increasing competition across various markets drives enterprises to innovate, which is especially important for the development of advanced markets. This enables companies to improve their competitiveness and respond more swiftly to changes in market demand. The synergy between marketing and logistics strategies has an even greater impact on a company's economic performance. The demand generated through marketing strategies depends on the effectiveness of logistics in ensuring timely delivery – this, in turn, strengthens customer satisfaction and

encourages repeat purchases. Innovations in logistics, such as real-time delivery tracking, not only improve the efficiency of logistics operations but also enhance brand perception, thereby supporting a company's marketing objectives. Thus, the integration of marketing and logistics strategies allows enterprises to maximise economic outcomes by reducing costs and improving customer service (Haji Ali Beigi, 2021).

The integration of marketing and logistics is a vital tool for increasing the economic efficiency of enterprises. This process aligns demand generation (marketing) with its fulfilment (logistics), enabling businesses not only to optimise costs but also to improve customer satisfaction and strengthen their competitive position in the market.

One of the key advantages of integrating marketing and logistics is the significant reduction in costs and the resulting increase in profitability. Incorporating logistics into the production process allows for lower procurement, transport, warehousing, administrative, storage, handling, and inventory management costs. By 2022, the logistics cost of transporting one tonne of grain from the central region to the ports of Odesa was approximately 30 USD. Following the blockade of seaports and the shift towards western borders, this figure rose to 170-180 USD per tonne. However, companies that implemented in-house logistics solutions and optimised their routes were able to reduce reliance on external carriers and partially mitigate rising costs. For instance, the cost of transporting grain via Ukrzaliznytsia (UZ) increased to 85 per tonne USD, but through route optimisation and the integration of logistics and marketing, some enterprises managed to reduce this cost by 10%-15% (Kopytko, 2023).

The integration of marketing and logistics also enhances company productivity and flexibility. The application of logistics methods can reduce inventory volumes by 30%-70%, cut production costs by 30%, and lower product movement expenses by 20% (The impact of logistics on the efficiency..., n.d.). Route optimisation, process automation, and the reduction of administrative costs contribute to lower overall expenditure and improve production rhythm – factors that are essential for maintaining market stability and ensuring rapid responses to shifts in demand. Enhancing customer-service quality and response speed is another result of integrating marketing and logistics. Enterprises that successfully align these two functions can react more rapidly to changes in consumer demand while maintaining a high standard of service. Consequently, repeat orders and customer loyalty increase, strengthening the firm's market position. For example, Kernel's Open Agribusiness programme (n.d.), which combines digital services with innovative logistics solutions, has improved the company's reputation and client trust, leading to greater satisfaction and long-term partnerships (Drive the Agribusiness of Ukraine, 2018). Flexibility and adaptability are further benefits of integration: the swift adjustment of production and supply to demand fluctuations enables firms not only to remain competitive but also to capture new market share.

Effective integration also allows companies to harness digital technologies that accelerate order processing, enhance fulfilment accuracy, and boost customer satisfaction. Research indicates that automating logistics processes can increase order-fulfilment speed by 30%-50% and accuracy to 98%-99% (Shkorina, 2024). Digital tools such as Big Data analytics, artificial intelligence (AI), the Internet of Things (IoT), and Global Positioning System (GPS) monitoring provide supply-chain transparency and improve the management of logistics operations.

Overall, the integration of marketing and logistics enables agricultural companies to reduce costs, improve efficiency, enhance service quality, and maintain sustainable development even during times of crisis. This strategic alignment allows companies to strengthen their competitive position, expand into new markets, and secure strong customer loyalty – foundations for long-term growth and resilience.

Assessing the economic effectiveness of marketing and logistics strategies

The integration of marketing and logistics in Ukrainian agricultural enterprises has become a key driver of increased revenues and reduced costs. Through the adoption of modern marketing strategies, agricultural companies have optimised their operations, improved profitability,

and achieved notable economic outcomes – even in the face of war and economic hardship.

Revenue growth has been one of the main benefits of combining marketing and logistics strategies. In 2023, the total revenue of the top ten agricultural companies increased by 35%, reaching 86.57 billion UAH – almost 1.5 times higher than before the onset of the full-scale war. In 2024, the total revenue of Ukrainian agricultural enterprises reached 2.4 trillion UAH, which is 2.6 times greater than in 2023. The highest revenues were recorded in Vinnytsia (292.8 billion UAH), Cherkasy (265.3 billion UAH), and Poltava (216.2 billion UAH) regions (GrainTrade, 2025). Notably, Myronivska Poultry Farm increased its revenue by 1.5 times, while the Kernel Group grew by 27% compared to 2022. This growth was made possible by rising prices for agricultural raw materials, the recovery of export activity, and the reduction of logistics costs. For certain companies, such as Ptakhokompleks Dniprovskyi and Zakhidnyi Buh, revenues increased by 30% and 25% respectively, demonstrating the effectiveness of marketing strategies even under challenging conditions (The income of agricultural industry leaders..., 2024).

Cost reduction is another significant achievement following the integration of marketing strategies. The use of digital platforms for transport monitoring and inventory management enables agricultural enterprises to avoid unnecessary expenses, respond quickly to delays, optimise routes, and minimise losses during transport and storage. The adoption of innovative technologies such as GPS tracking, automated inventory management systems, and blockchain has helped reduce lossrelated risks and improve control over the conditions in which goods are transported and stored – particularly crucial for perishable products. These measures contributed to a 15%-20% reduction in storage and transportation costs and a 10%-15% decrease in product losses (NISS, 2024).

Inventory optimisation and accurate demand forecasting have also become essential tools for lowering operational costs. Marketing strategies allow agricultural companies to plan production and storage more precisely, which in turn reduces excess inventory and cuts storage expenses. This led to a 10%-15% reduction in operational costs. In 2023, inventory optimisation and the implementation of digital management tools enabled large agricultural companies to reduce storage and logistics expenses by 12%-18% (NISS, 2024). By 2024, the digitalisation of logistics processes resulted in a significant reduction in export logistics costs across Ukraine's agricultural sector. The cost of delivering agricultural products to the ports of Greater Odesa fell by 33% compared to 2022. The introduction of digital platforms for transport monitoring, route optimisation, and automated document processing allowed agricultural enterprises to manage inventory more effectively, avoid unnecessary expenses, and increase supply chain efficiency (Mind, 2024).

Profitability in the agricultural sector also improved following the implementation of marketing strategies. In 2023, the profitability rate of the sector stood at 14.1% – a considerable decline from 37.8% in 2021. However, 78% of agricultural enterprises remained profitable, with net profits from the cultivation of grain, leguminous, and oilseed crops reaching 45.5 billion UAH (Agroportal, 2024). In 2024, the profitability of rapeseed approached 60%, soya up to 40%, and sunflower up to 30%. This marked growth, compared to 2023, was largely attributed to higher agricultural commodity prices, renewed export activity, and reduced logistics costs. For example, the profitability of sunflower in 2024 reached 45 USD per tonne (compared to a loss in 2023), soya reached 83 USD per tonne (69 USD per tonne in 2023), and rapeseed reached 78 USD per tonne (5 USD per tonne in 2023) (SuperAgronom, 2024). In 2023, most livestock products remained profitable, and in January 2024, the profitability of milk and poultry meat production increased due to lower feed costs. However, the profitability of beef and pork declined due to falling meat prices (Opendatabot, 2024). In 2024, the agricultural sector's revenues grew by 33%, while profits nearly doubled. The total turnover of the sector reached 1.3 trillion UAH, with profits amounting to 127 billion UAH – a significant increase compared to 74 billion UAH in 2023 (Agroreview, 2025). Thus, the integration of marketing strategies in Ukraine's agricultural enterprises not only contributed to increased revenues but

also helped reduce costs, optimise inventory management, improve profitability, and ensure financial resilience under challenging economic conditions. These outcomes confirm that modern marketing approaches are a key factor in ensuring the stability and continued development of Ukraine's agricultural sector.

Logistics strategies are essential tools for enhancing the efficiency of agricultural enterprises, as they enable cost reduction and optimisation of production, transportation, and storage processes. The integration of marketing and logistics helps enterprises maintain sustainable development while remaining competitive amid ongoing economic challenges. Inventory management is one of the key strategies for reducing costs and improving the operational efficiency of agricultural enterprises. By implementing modern inventory management systems, such as automated platforms, it is possible to minimise surplus stock, reduce storage costs, and improve capital turnover. This allows enterprises to lower expenses associated with warehouse maintenance and reduce the risk of product shortages or overstocking (Rakyta *et al.*, 2022).

Transportation of goods is another vital component of logistics strategies. By 2024, the average cost of grain delivery to Ukrainian ports stood at 33 per tonne USD – twice as high as in EU countries and 50% higher than in the USA – due to inefficient logistics schemes and complex documentation. According to transport companies, inefficiencies in logistics caused Ukrainian agricultural producers to lose up to 20 USD per tonne of product (Agrokebety, n.d.). Following the implementation of optimisation measures – such as cooperation with experienced logistics operators, automation of accounting and planning, and route optimisation – transportation and storage costs decreased by an average of 12%-18%. These improvements significantly reduced fuel and storage expenses, thereby enhancing the overall efficiency of the supply chain (Agrologistics, n.d.).

Storage of products is also a critical component of logistics strategies. The use of automated warehouse management systems not only helps reduce storage costs but also minimises the risk of product losses due to spoilage or damage. Investments in automation and warehouse condition monitoring – such as temperature and humidity control technologies – enable enterprises to maintain product quality and lower processing costs. Table 1 presents the key logistics strategies and their economic viability.

According to the logistics strategies outlined above, optimising inventory, transportation, and storage significantly reduces costs and improves the efficiency of agricultural enterprises. Optimising every stage of the logistics process is essential for maintaining competitiveness in an unstable market. Table 2 presents digital platforms that are actively used to optimise logistics in the agricultural sector.

Table 1. Key logistics strategies and their economic viability

Logistical strategies	Economic viability
Inventory management	Optimising inventory levels helps reduce storage costs, lowers the risk of shortages or overstocking, and improves capital turnover
Transportation	Optimising transport routes reduces the cost of product delivery, improves supply chain efficiency, shortens delivery times, and cuts fuel expenses
Storage	Proper organisation of product storage reduces the risk of losses from spoilage or damage, lowers storage costs, and creates better conditions for incoming deliveries

Source: compiled by the authors based on YC.Market (2023), Agrologistics (n.d.), Agrokebety (n.d.)

Table 2. Digital platforms for optimising logistics in the agricultural sector

Digital platforms	Description
AgroOnline	A comprehensive online platform for automating agricultural business management. It includes warehouse accounting, inventory control, production planning, financial analytics, electronic document management, and agronomic oversight
Uagro	An information platform for a transparent agricultural market that facilitates trade in grain, fertilisers, and other goods. It features a call centre that gathers real-time data on supply and demand

Table 2, Continued

Digital platforms	Description
TopAgro	A software product for managing agricultural enterprises, offering transparency in document flow, financial and economic analysis, crop yield tracking, equipment monitoring, and market pricing
AgriSync	A platform supporting farmers via video communication with technical experts. It assists with resolving production issues and implementing new technologies
AirFarm	A mobile application for farmers that provides analytics on seeding, irrigation, fertiliser application, and weed control. It operates offline and fosters user communities
Agrifinance	An online platform for accessing finance, helping farmers obtain credit and financial services through cooperation with certification bodies and exporters
Agrocontrol	A system for integrated management of agricultural enterprises, including crop harvesting oversight, automated accounting, and minimisation of human error

Source: compiled by the authors based on Stfalcon (2021), Propozitsiya (2022)

Digital platforms play a crucial role in improving the logistics processes of agricultural enterprises. They facilitate the automation of inventory management, transportation, and storage, leading to significant cost reductions and improved efficiency. The use of such platforms enables agricultural businesses to adapt to rapidly changing market conditions while maintaining their competitiveness. The integration of marketing and logistics strategies, alongside the implementation of modern digital platforms, allows agricultural enterprises to reduce costs, enhance operational efficiency, and strengthen their market position. Optimising logistics processes and adopting digital tools have become essential for the development of the agricultural sector, ensuring stable growth and long-term resilience.

The introduction of Automated Transport Systems (ATS) in processing enterprises represents a significant step towards enhancing logistics processes' efficiency and reducing costs. The deployment of advanced technologies such as autonomous transport robots, automated conveyor lines, and route optimisation powered by artificial intelligence can substantially cut expenses related to transportation, storage, and inventory management. In particular, automating transport operations can reduce logistics costs by 10%-20% (Vorecol, n.d.). This is achieved through the elimination of manual handling, the streamlining of material flows, and the reduction of unnecessary product movement, which collectively lower transport costs, minimise waiting times, and help prevent bottlenecks.

In addition to reducing transportation costs, automation also significantly lowers labour expenses. Automated systems reduce the need for manual intervention in the movement, packaging, and sorting of goods, thereby decreasing personnel costs. With the ability to operate continuously, automation increases throughput while reducing the need for overtime and variable labour expenses. This substantially improves the overall operational efficiency of the enterprise, while keeping labour costs low.

Automation also enables the optimisation of warehouse space usage. Reducing the need for excessive storage helps to lower warehousing expenses and enhances the efficiency of existing space utilisation. Synchronising transportation with production requirements, along with the use of automated high-bay warehouses and real-time inventory monitoring systems, contributes to lower storage costs by optimising inventory levels and minimising risks associated with overstocking or stockouts (MyCarrier, 2024).

The integration of technologies for real-time monitoring, predictive maintenance, and route optimisation reduces unexpected delays and enhances transport reliability. The implementation of these technologies improves the accuracy of demand forecasting, which in turn lowers inventory holding costs and improves delivery timeliness. Moreover, real-time monitoring and the optimisation of logistics processes reduce the capital required for maintaining large inventories, thereby decreasing financial expenditure. Table 3 outlines the key performance indicators for the implementation of automated transport systems in processing enterprises.

Table 3. Key performance indicators for the implementation of ATS in processing enterprises

Indicator	Reduction in costs (%)
Transportation costs	10-20
Storage costs	10-15
Labour costs	40
Increase in productivity	25
Inventory cost reduction	20

Source: Vorecol (n.d.)

The implementation of automated transport systems in processing enterprises enables a reduction in transportation, storage, inventory management, and labour costs. These economic benefits contribute to increased productivity and lower operational expenses, enhancing the competitiveness of enterprises in the market. The most notable reduction is observed in labour costs – which was observed by up to 40% – reflecting a significant decrease in the need for manual labour due to the automation of in-plant logistics and loading/unloading operations. At the same time, transportation costs are reduced by 10%-20%, largely owing to more efficient route planning, decreased downtime, and the integration of ATS with supply chain management systems. Reductions in storage costs (10%-15%) and inventory costs (20%) indicate improvements in demand forecasting accuracy and more flexible warehouse resource management. A 25% increase in productivity represents a generalised indicator of the comprehensive impact of ATS, encompassing faster product handling, reduced idle time, and greater efficiency throughout the operational cycle. Taken together, these indicators confirm that the implementation of ATS not only reduces costs but also enhances the competitiveness of enterprises in the processing industry. In 2023-2024, the processing enterprise Odeskyi Food Plant implemented an automated transport system to facilitate the movement of raw materials and finished products between production lines and the warehouse. This enabled a 28% reduction in cargo movement time within the enterprise, a 19% decrease in in-plant logistics costs, and a 35% reduction in equipment downtime caused by transport delays. Moreover, the implementation of ATS contributed to improved occupational safety by reducing the number of accidents (Logistics in Ukraine, 2024).

Thus, the introduction of automated transport systems in processing enterprises facilitates cost reduction, improved efficiency, and enhanced profitability. Automation not only cuts expenses but also increases organisational flexibility and the ability to swiftly adapt to market changes.

Recommendations for improving marketing and logistics processes

Marketing and logistics processes in agricultural enterprises are key components that directly affect their efficiency and economic stability. In the face of volatile market conditions, rapid shifts in supply and demand, and high logistics costs, effective management of marketing and logistics operations becomes a critical success factor for agribusinesses.

Financial risks associated with instability in the agricultural commodity market can significantly impact enterprises. Rising raw material prices, currency fluctuations, and seasonal changes in supply and demand may lead to serious financial challenges. To mitigate these risks, agricultural enterprises are advised to adopt hedging strategies and financial planning measures. These approaches help minimise exposure to price volatility in agricultural commodities. The use of futures contracts and other hedging instruments allows enterprises to lock in prices for future delivery, thereby ensuring greater income stability. It is also advisable to invest in analytical platforms for demand forecasting and pricing. The use of systems that automatically analyse data on demand, supply, weather conditions, and market trends enables businesses to prepare in advance for changes in prices and consumer demand, thereby reducing financial risks.

Risk diversification is another important tool for minimising financial losses. A key strategy in this context is the diversification of

marketing and logistics approaches. This may include working with multiple suppliers, pursuing export strategies targeting different markets, and applying various marketing tools. Diversification helps reduce dependence on a single income source or sales market, thereby enhancing financial stability.

Effective logistics process management is one of the critical factors influencing the cost structure of agricultural enterprises. Given the high costs associated with transportation and storage, particular attention must be paid to optimising these processes. Below are several recommendations to improve logistics efficiency. The use of automated inventory management systems significantly reduces storage costs, as these systems support more accurate planning of production volumes and deliveries while also minimising human error. The integration of digital platforms for inventory and transport management helps reduce manual mistakes, improve forecasting accuracy, and avoid overstocking or stockouts. This, in turn, lowers the cost of storage and transportation by enabling more efficient planning of production volumes and delivery schedules.

Route optimisation is another key measure for reducing transportation costs. With technologies such as GPS tracking, businesses can streamline delivery routes, leading to savings on fuel and reduced delivery times. Optimisation also minimises unnecessary movements and lowers overall transport expenses. The use of innovative technologies in product storage can significantly reduce storage costs, particularly for perishable goods. Automated warehouses and real-time monitoring of storage conditions help lower expenses while ensuring better quality preservation.

Integrating marketing and logistics strategies enhances the profitability of agricultural enterprises by reducing costs and improving coordination between marketing and logistics departments. Combining marketing tools with logistics processes enables companies to respond more effectively to fluctuations in demand and ensure timely delivery. This improves customer satisfaction and increases repeat orders, thereby contributing to revenue growth.

The development of strategic partnerships with suppliers and customers helps optimise supply chains, reduce expenses, and improve service quality. Such partnerships benefit both parties by lowering operational costs and boosting competitiveness. The use of digital platforms for marketing campaign management enables agricultural enterprises to better target consumer needs, leading to more efficient marketing planning and reduced advertising expenditure.

The implementation of effective marketing and logistics strategies in agricultural enterprises is a key factor in reducing costs, improving efficiency, and increasing profitability. Optimising logistics routes, introducing automated inventory management systems, and integrating these with marketing strategies can deliver significant financial benefits, supporting the stable development of enterprises in a competitive market. Data illustrating the impact of such technologies on costs and operational efficiency are presented in Table 4, which outlines the main statistical indicators related to cost reductions and efficiency gains following the implementation of new logistics systems.

Table 4. Statistical data on the implementation of innovative logistics technologies in agricultural enterprises

Technology	Reduction in costs (%)	Increase in efficiency	Implementation period
Automated inventory management systems	10-15	Improved stock forecasting accuracy	6-12 months
Logistics route optimisation	10-12	Reduced fuel costs, shorter delivery times	3-6 months
Automated warehousing	12-18	Lower storage costs	12-18 months

Source: compiled by the authors based on I. Zrybnieva (2024)

Table 4 illustrates the impact of implementing innovative logistics technologies on the efficiency of agricultural enterprises. The greatest cost reduction is achieved through

automated warehousing – up to 18%, highlighting the high potential of this technology for lowering storage expenses. Meanwhile, automated inventory management systems can reduce costs by 10%-15% by improving forecasting accuracy and reducing excess stock. Although logistics route optimisation demonstrates a slightly lower level of savings (10%-12%), it delivers a significant reduction in fuel costs and delivery times – crucial for enterprises with large-scale transport operations. In terms of implementation periods, route optimisation solutions are the quickest to deploy (3-6 months), whereas automated warehouses require the longest (12-18 months) due to the complexity of technical and infrastructure requirements. Thus, automated warehousing offers the highest potential for cost savings, while route optimisation stands out in terms of implementation speed.

The adoption of effective marketing and logistics strategies in agricultural enterprises is a key factor in reducing costs, enhancing efficiency, and increasing profitability. Optimising logistics routes, implementing automated inventory management systems, and integrating these processes with marketing strategies enable enterprises to achieve substantial financial benefits, supporting their stable development in a competitive market.

DISCUSSION

Digital technologies have become indispensable tools for improving the efficiency and resilience of supply chains in the contemporary agricultural sector. By integrating marketing and logistics through digital platforms, agricultural enterprises can reduce costs, enhance resource management, and strengthen their competitiveness. Adapting to new market conditions, therefore, demands the adoption of innovative strategies and technologies that optimise operational processes. The analysis confirmed the pivotal role of logistics in lowering costs and boosting the efficiency of agricultural enterprises, aligning with the findings of Y. Li (2024). However, whereas Y. Li's research highlighted e-commerce as a means of supply-chain integration, the present study concentrated on the interaction between logistics and marketing as a driver of Ukrainian agricultural enterprises' economic performance. In addition, Y. Li developed econometric models to assess the impact of logistics on economic growth, while the current study formulated practical recommendations for enterprises operating with limited resources.

In the study by D.H.S. Keefe *et al.* (2024), which focused on the digitalisation of agricultural supply chains in Association of Southeast Asian Nations countries, particular attention was given to the implementation of IoT and blockchain technologies to enhance resilience and efficiency. In contrast, the present research examined the potential for adopting similar technologies within the local context of Ukraine's agricultural market and its specific challenges. The research of M. Sauvagerd *et al.* (2024) explored global trends in platformisation, with an emphasis on processes of oligopolisation and interactions between agricultural and technology corporations. By comparison, this study concentrated on the use of digital platforms by regional agricultural enterprises to reduce costs and improve competitiveness. There were also thematic intersections with the research by R.R. Panigrahi *et al.* (2024), which addressed supply chain digitalisation with a focus on sustainable development and the needs of small and medium-sized enterprises. While R.R. Panigrahi *et al.* highlighted barriers such as financing and infrastructure, the present study focused on practical approaches to integrating marketing and logistics in order to reduce costs and improve efficiency in the Ukrainian context.

A comparison with the study by N. Wei *et al.* (2022) revealed a shared approach to the use of digital technologies for enhancing the efficiency of agricultural supply chains. Both studies confirmed the importance of logistics as a tool for reducing costs. However, while N. Wei *et al.* focused primarily on addressing the challenges of high logistics costs and inadequate infrastructure in China – particularly the improvement of cold chain systems to preserve product quality – this study explored logistics in conjunction with marketing. The emphasis here was placed on the integration of marketing and logistics solutions to optimise costs for Ukrainian agricultural enterprises, applying practical strategies tailored to the specifics of the domestic market.

The study by M. Yuan *et al*. (2024) also shared the central idea of integrating logistics and marketing to improve the efficiency of the agricultural sector. However, the conceptual approaches differed. In M. Yuan *et al*., the focus was on employing blockchain technologies and the Internet of Things (IoT) to ensure resilience and transparency in global agricultural supply chains. In contrast, the present study focused primarily on local Ukrainian enterprises operating under resource constraints. The primary objective here was to optimise costs and enhance operational efficiency through the implementation of integrated digital solutions. This study and that of G. Zhao *et al*. (2024a) shared a common emphasis on digital technologies for improving the resilience and efficiency of agricultural supply chains. Both articles highlighted the importance of adopting advanced technologies such as IoT, blockchain, and digital platforms to reduce costs and increase transparency in agri-supply systems. The study by G. Zhao *et al*. (2024b) placed greater focus on analysing the barriers to implementing Industry 4.0 technologies, particularly in developing countries, where challenges such as limited funding, inadequate infrastructure, and low levels of digital literacy prevail. It addressed the difficulties agricultural enterprises face when adopting innovative technologies on a global scale. In contrast, M. Oklander *et al*. (2024) explored the economic dimensions of implementing Industry 4.0 marketing technologies within Ukraine's agroindustrial sector, with an emphasis on their impact on business efficiency and the sector's adaptation to digital transformation. This study also acknowledged the broader challenges faced by agricultural enterprises during the global transition to innovation-driven practices.

This study, along with the research by N. Kanellos *et al.* (2024), emphasised the importance of digital technologies in enhancing the efficiency of agricultural supply chains, with a particular focus on marketing strategies for cost reduction. However, while N. Kanellos *et al.* concentrated more on optimising advertising expenditure through web data analysis; the present study focused on the integration of marketing and logistics to optimise costs in Ukraine's agricultural sector. Both studies underlined the importance of efficient resource utilisation, though their approaches to technology application and research contexts differed significantly. Similarly, the study by M. Puma-Flores & I.M. Rosa-Díaz (2024) recognised the value of marketing strategies in improving the performance of agricultural companies. However, their emphasis was placed on tools such as participation in international exhibitions, brand presence, and product certification to enhance reputation and facilitate access to foreign markets. In contrast, this study considered marketing and logistics as an integrated system aimed at reducing costs within the domestic market and improving the operational efficiency of large agricultural enterprises in Ukraine.

The research conducted by L. Nguyen-Thi-Thuy *et al.* (2024) shared a similar objective with the present study – improving the efficiency of agricultural supply chains. However, their focus was on the technical efficiency of agro-processing enterprises, highlighting the role of political support and infrastructure development in Vietnam. In contrast, this study was more concerned with the application of digital technologies to optimise agricultural supply chains in Ukraine through the integration of marketing and logistics. Both studies emphasised the importance of government support; however, the present research placed greater focus on technological innovation rather than on technical or political aspects.

The study by E. Begimkulov & D. Darr (2023) concentrated on scaling solutions for small and medium-sized enterprises in the agri-food sector. In contrast, the current study targeted large agricultural enterprises, demonstrating how the integration of marketing and logistics strategies can lead to systematic cost savings and increased productivity. Both E. Nnko *et al.* (2024) and this study shared a common emphasis on the use of digital technologies to improve the efficiency of agricultural enterprises. Each highlighted the importance of integrating marketing and logistics to reduce costs. However, while E. Nnko *et al.* focused on the resilience of agricultural supply chains in the context of climate change, the current study placed greater emphasis on economic indicators and the financial sustainability

of enterprises. E. Nnko *et al.* examined the social and environmental dimensions, whereas this research focused on cost optimisation through advanced technologies.

Digital technologies are a vital driver of transformation in agricultural supply chains, as they support cost reduction, enhance operational efficiency, improve information exchange, and enable more effective logistical planning. The use of marketing-logistics strategies that integrate cuttingedge technologies allows enterprises not only to optimise costs but also to enhance their adaptability in an increasingly volatile market and competitive environment. The integration of such technologies is key to achieving sustainable development, ensuring flexibility, and strengthening the competitiveness of the agricultural sector in a global context.

CONCLUSIONS

The study demonstrated that the integration of marketing and logistics strategies in agricultural enterprises is a key factor in enhancing their competitiveness amid shifting economic conditions and global challenges. According to the data obtained, effective management of logistical processes and the application of targeted marketing strategies can significantly reduce costs, improve operational efficiency, and ensure financial stability.

In 2024, the total revenue of agricultural enterprises in Ukraine reached 2.4 trillion UAH, which is 2.6 times higher than in 2023. Notably, the company Myronivska Poultry Farm increased its revenue by 1.5 times, while the Kernel group of companies saw a 27% rise compared to 2022. These results were driven by rising prices for agricultural raw materials, the recovery of export activity, and a reduction in logistics costs. For example, the cost of transporting grain fell by 10%-15% following the optimisation of logistics routes, which helped reduce expenses related to both transportation and storage. Furthermore, the introduction of digital platforms for inventory and transport management enabled agricultural enterprises to lower storage and transportation costs by 12%-18%. This has helped reduce the risk of product losses due to improper storage or delays in delivery. For example, automated inventory management systems reduce storage costs by 10%-15% and improve the accuracy of stock forecasting. The use of GPS technologies to optimise logistics routes has lowered grain transportation costs from 170-180 USD to 85 USD per tonne, resulting in an overall reduction of 10%-15% in transport expenses.

Analysis also showed that the profitability of agricultural enterprises increased following the integration of marketing strategies. In 2023, the profitability of the agricultural sector stood at 14.1%, a significant decline compared to 2021 (37.8%), yet the majority of enterprises (78%) remained profitable. A marked increase in profitability was recorded in the production of oilseed crops such as rapeseed and soybeans. For instance, rapeseed profitability reached 60% in 2024, a substantial rise compared to previous years. In 2024, agricultural revenues grew by 33%, with profits nearly doubling. The total business turnover reached 1.3 trillion UAH, and profits amounted to 127 billion UAH – significantly higher than 74 billion UAH in 2023. The integration of digital technologies into logistics processes was another key factor in reducing operational costs. The automation of workflows and the use of enterprise management platforms enabled a reduction in transport and storage expenses by 12%-18%. These innovations also improve product quality and reduce the risk of losses during transportation and storage – particularly important for goods with limited shelf life. Through the digitalisation of logistics processes, Ukraine's agricultural sector significantly reduced export logistics costs in 2024. Compared to 2022, the cost of delivering agricultural products to the ports of Greater Odesa fell by 33%. The integration of marketing and logistics processes has enabled enterprises not only to cut costs but also to boost productivity – particularly through the automation of inventory management and logistics routing. As a result, transport costs decreased by 10%-20%, while labour costs fell by 40%.

Future research prospects include a deeper exploration of the impact of digital technologies on the integration of marketing and logistics processes, as well as an analysis of how

agricultural enterprises adapt to changes in international markets amid global economic challenges. The limitations of the study lie in the lack of detailed analysis of the role of government support in the effectiveness of marketing-logistics strategies and the limited number of concrete examples from agricultural enterprises operating under wartime conditions.

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Валерій Бондаренко
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-5929-7158
Віолета Гераймович
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-4721-5100
Юлія Гаврилюк
Кандидат економічних наук
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-0774-3494
Олена Барилович
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-1732-3637
Алла Рябчик
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0001-6290-3609

Маркетингово-логістичне забезпечення підприємств аграрного сектору і переробних підприємств

Анотація. Метою статті було вивчення впливу маркетингово-логістичних стратегій на економічні показники аграрних підприємств в Україні, зокрема на їх конкурентоспроможність, оптимізацію витрат та зростання доходів. Для досягнення цієї мети використовувалася методологія, що включала аналіз економічних аспектів маркетингово-логістичного забезпечення аграрних підприємств, використовуючи наукові публікації, галузеві звіти та практичні дані. Для оцінки ефективності застосовувалися кількісні та якісні методи дослідження, зокрема аналіз фінансових показників підприємств, дослідження логістичних та маркетингових стратегій, а також аналіз впливу цифрових технологій на ефективність бізнес-процесів. Результати дослідження показали, що інтеграція маркетингово-логістичних стратегій дозволила аграрним підприємствам значно знизити витрати, зокрема на транспортування і зберігання продукції. Впровадження цифрових платформ для управління запасами та оптимізації транспортування призвело до скорочення витрат на 12-18 %. У 2024 році загальний дохід аграрних підприємств України досяг 2,4 трлн грн, що перевищило показник 2023 року у 2,6 рази. Найвищі обсяги доходів зафіксовано у Вінницькій (292,8 млрд грн), Черкаській (265,3 млрд грн) та Полтавській (216,2 млрд грн) областях. Впровадження автоматизованих транспортних систем знизило витрати на транспортування на 10-20 %, а застосування Global Positioning

System-моніторингу для оптимізації маршрутів призвело до зниження витрат на паливо на 15 %. Отримані результати підтвердили, що ефективне використання маркетингово-логістичних стратегій стало ключовим чинником для забезпечення конкурентоспроможності аграрних підприємств. Інтеграція маркетингу і логістики дозволила знижувати витрати, покращувати ефективність операцій і забезпечувати фінансову стійкість підприємств в умовах глобальних економічних викликів. Впровадження цифрових інструментів і автоматизація процесів стали важливими факторами для досягнення високої продуктивності та зменшення витрат. Практичне значення дослідження полягає в розробці рекомендацій щодо оптимізації маркетингово-логістичних процесів аграрних підприємств, що дозволяє знизити витрати, підвищити ефективність управління та забезпечити фінансову стабільність у умовах змінюваних ринкових умов

Ключові слова: конкурентоспроможність; інновації; оптимізація запасів; транспортування; прогнозування попиту

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Yevhenii Lanchenko*
Doctor of Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0003-0894-4885

Volodymyr Ivchenko
PhD in Agricultural Sciences, General Director
Ukrainian Research Institute of Agricultural Productivity
03035, 2 Solomyanska Sq., Kyiv, Ukraine
https://orcid.org/0009-0000-2035-2976

Oleksandr Nosikov
PhD in Sociological Sciences, Leading Researcher
Ukrainian Research Institute of Agricultural Productivity
03035, 2 Solomyanska Sq., Kyiv, Ukraine
https://orcid.org/0009-0006-3465-9665

Financial support for rural development in territorial communities

Abstract. The study aimed to identify the peculiarities of the functioning of the system of financial support for rural territorial communities and to assess its ability to ensure rural development in the context of new managerial and economic challenges. The research methodology was based on an analysis of the dynamics of rural communities' revenues in 2021-2024, the structure of local budget revenues, capital expenditures, and off-budget financing. The study found that the total revenue of rural communities increased from 29.0 billion UAH in 2021 to 40.4 billion UAH in 2024. In 2023, the average amount of local taxes and fees per capita reached 2,530.6 UAH, which exceeded the figure for 2021 (2,190.4 UAH), and according to the analysis of 1,331 communities, in 2024 it was approximately 8,183 UAH (excluding transfers). In 2024, personal income tax (36.3%) and local taxes (12%) accounted for the bulk of revenues, while the share of intergovernmental transfers remained high at around 38%. Capital expenditures also increased: in 2024, the average amount of such expenditures was 2,075.8 UAH per capita. Extra-budgetary resources were noted to be substantial: more than 5,000 entrepreneurs received loans worth over 20 billion UAH, and dozens of grant projects were implemented in communities in at least six regions. The findings of the study confirmed that financial flexibility, strategic planning, effective administration of

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*Corresponding author

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local taxes and attraction of external resources are key factors in the stable development of rural communities even in times of crisis. The results of the study can be used by local governments to improve budget planning mechanisms, increase the financial independence of communities and attract additional resources for sustainable rural development

Keywords: investment; income; tax; budget; strategic planning; rural development; entrepreneurship

INTRODUCTION

Financial self-sufficiency of communities, especially those located in rural areas, where the level of economic activity is lower compared to cities, is a substantial task. It is the financial capacity of communities that determines their ability to address priority development issues, modernise infrastructure, provide social services, support small businesses, and stimulate employment. At the same time, due to the war, economic instability, and changes in donor approaches to aid, communities face new risks that require adaptive and strategically sound solutions.

In the context of declining budget revenues and increasing financial burden on local governments, the issue of the resource capacity of rural areas is of relevance. The study by O. Podzizei & T. Korobchuk (2023) revealed the dynamics of local budget revenues and expenditures in the context of war, analyses the budget deficit and the sources of its coverage, through transfers and international assistance. The study emphasised that despite maintaining financial autonomy, communities face a lack of resources to implement investment projects. The formation of effective rural financing is necessary to achieve the goals of sustainable development in a resource-limited environment. L. Romanchuk *et al.* (2024) studied the European experience of supporting rural communities, focusing on EU cohesion policy instruments: grants, loans, guarantees, and investments. The study proved that the integrated use of these instruments contributes to socio-economic sustainability.

In the context of decentralisation, one of the key challenges is to ensure equal access to resources, services and development opportunities for the rural population. M. Bezpartochnyi & O. Bezpartochna (2024) also covered the issue. The study analysed the impact of financial decentralisation and territorial marketing on the inclusive development of rural communities in the Lviv region. In particular, the study analysed budgetary indicators, the level of political, economic and social inclusion, and surveyed active groups of community members. The study determined that the indices of political inclusion are the highest due to the availability of administrative services and the effectiveness of management decisions, while economic inclusion is limited by low access to resources. Under martial law, there is a growing need for new approaches to financing the development of territories. T. Zheliuk & A. Zhukovska (2022) analysed the possibilities of attracting budgetary, grant and crowdfunding resources to create a civil protection system in communities, emphasising an inclusive approach. The study also considered the potential of effective land management to increase revenues.

The uneven financial capacity of local communities remains a challenge for decentralisation. T. Zaiats *et al.* (2024) analysed the dynamics of the budgetary capacity of communities in the pre-war and war periods, identifying the key factors of population, subsidisation, and tax capacity. The study proposed a model for the formation of capable communities, revealing significant socio-economic differentiation and limited effectiveness of horizontal equalisation. The financial autonomy of territorial communities in Ukraine is a key factor in their sustainable development in the context of decentralisation. P. Fuhelo *et al.* (2022) studied the sources of local budget revenues, the assessment of the effectiveness of financial support, and the dynamics of intergovernmental transfers in 2016-2020. The study emphasised the benefits of expanding the list of local taxes, increasing the volume of communities' revenues, and moving to direct intergovernmental relations with the state.

The insufficient level of financial independence of local budgets and the imbalance in the horizontal alignment of resources hinder the sustainable development of territorial

communities. R. Sodoma *et al.* (2022) analysed the impact of financial decentralisation in the context of adapting international experience and proposed a conceptual model of community development that integrates the potential of the budgetary, business, and household spheres. The study emphasised the importance of an effective system for monitoring the effectiveness of decentralisation and the need for a comprehensive reform of local government, including the redistribution of powers and resources. The insufficient coverage of rural communities with advisory services and the instability of their funding sources significantly hinders the development of local initiatives. A. Gaidutskyi (2024) studied the world experience of financing agricultural extension and the specifics of its application in Ukraine, analysing the contracting model of financing, which involves the provision of socially oriented services by non-governmental organisations at the expense of the state budget. The study has identified the advantages and disadvantages of the "demand-side" and "supply-side" approaches and proposed the creation of a special Fund for the Development of Extension with corporate governance.

Budget planning requires innovative tools, attracting additional funding and stimulating entrepreneurship. There are no clear approaches to assessing the effectiveness of financial mechanisms and analysing their interrelationships, as well as the integration of displaced agricultural enterprises into the local economy. The issues of combining security financing with long-term development instruments, incorporating internal migration, and aligning budget policy with sectoral reforms have not been sufficiently studied. Adaptation of financial policy to the conditions of crisis areas and interaction with alternative sources of funding also require attention.

The study aimed to identify ways to improve financial mechanisms to support rural development in the context of decentralisation and socio-economic instability. To achieve this goal, the following tasks were set: to analyse the structure and dynamics of local budget revenues and expenditures in rural communities; to explore the possibilities of attracting alternative sources of funding for the implementation of rural development projects in territorial communities.

MATERIALS AND METHODS

The study was practical in nature and covered the period of 2021-2024, which made it possible to trace changes in the financial support for the development of rural territorial communities in the context of budget policy transformations, including adaptation to new challenges of the management and tax systems. The study used system analysis to comprehensively examine the economic essence of financial support as a key for managing the development of territorial communities. Financial support was considered as a set of budgetary and extra-budgetary resources aimed at achieving the strategic and socio-economic goals of communities.

The analysis used a comparative analysis to assess the dynamics of rural territorial communities' revenues in 2021-2024, focusing on total revenues and their growth in difficult conditions (Decentralisation, 2025a; 2025b). The structure of local budget revenues for 2024 was analysed in detail, with the main share being personal income tax, as well as local taxes and intergovernmental transfers (Structure of local..., n.d.; Local taxes and..., n.d.). The share of each source in budget formation is considered, which makes it possible to determine the level of tax independence of communities. Particular attention was paid to the structure of local taxes: the share of the single tax, land fees, and rent in the overall revenue system was analysed (Decentralisation, 2024a). At the same time, the average amount of local tax and fee revenues per capita was studied, depending on the size of the community.

Capital expenditures as an indicator of the investment potential of communities were a separate analytical area of the study. The average amount of capital expenditures per capita and the share of such expenditures in the overall structure of budgets were determined (Local budgets – 2024, 2024). These data were considered as an indicator of the ability of communities to invest in infrastructure, education, healthcare and other priority areas. An important component of the study was the examination of mechanisms for attracting extra-budgetary resources. In particular, the study examined the participation of communities in the state programme "Affordable Loans" (Privatbank, n.d.), and analysed cooperation with international partners: Research

Institute of Organic Agriculture (FiBL, Switzerland), SAFOSO AG (Switzerland) (SAFOSO, n.d.), United States Agency for International Development (USAID) (USAID, n.d.) and Kymonix International (n.d.) (Kurkul, 2024).

In 2023-2024, the study analysed the attraction of grant support implemented by Corteva Agriculture (n.d.) under the TalentA programme (Corteva, n.d.). The role of charitable foundations in mobilising additional funds is also investigated. The study examined intergovernmental transfers as an important source for compensating for financial imbalances, particularly in 2022-2024, and identified their importance for small and frontline communities (Local taxes and..., n.d.). The study also included an assessment of the implementation of revenue targets in the communities. Based on the materials studied, directions for improving the financial support for rural development in the local governance system were developed, and the case study method was used to analyse specific practices of attracting extra-budgetary resources implemented in certain Kyiv, Cherkasy, Zaporizhzhia, Chernihiv and Vinnytsia regions (Local budgets – 2024, 2024; Berezyuk, 2024).

RESULTS AND DISCUSSION

Fundamentals of financial support for the development of rural areas of Ukraine

Financial support is a key tool for managing the development of territorial communities, since it is through the effective formation and use of financial resources that management decisions, strategic plans and local initiatives are implemented. The economic essence of financial support is the accumulation, distribution and rational use of monetary resources, which are formed both from domestic revenues and through intergovernmental transfers, grants, investment and credit support.

The dynamics of rural communities' revenues show a gradual increase in their financial capacity, despite the difficult military and economic conditions. While in 2021, the total revenues of rural communities amounted to 29.0 billion UAH, in 2022, despite the war, this figure remained at a similar level. Already in 2023, revenues increased to 35.2 billion UAH, and in 2024, they reached 40.4 billion UAH, which is evidence of the stable recovery and adaptation of communities to new conditions. Per capita, the average amount of local tax and fee revenues increased from 2,048 UAH in 2022 to 2,530.6 UAH in 2023, exceeding the pre-war figure of 2,190.4 UAH in 2021, and reached approximately 8,183 UAH in 2024 (excluding transfers), according to an analysis of 1,331 communities (Decentralisation, 2025a). Figure 1 shows the dynamics of rural territorial communities' revenues in 2021-2024.

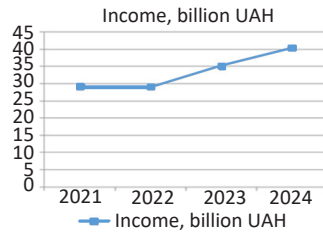

Figure 1. Revenue dynamics of rural communities in 2021-2024

Source: compiled by the authors based on Decentralisation (2025a)

In the structure of local budget revenues in 2024, the main share was accounted for by the personal income tax (36.3%) and local taxes and fees (10-12%). Thus, the total share of internal revenues reached 46-48%, which indicates the growing independence of communities in generating revenues (Structure of local..., n.d.). At the same time, intergovernmental transfers remain an important source of financial support: subventions accounted for 19.0% and grants for 7.5%, or 25% of total revenues (Local taxes and..., n.d.). In rural communities, given the limited tax base, this share may be even higher. Figure 2 shows the distribution of the revenue structure in 2024.

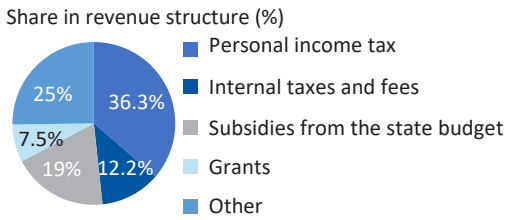

Figure 2. Structure of local budget revenues in 2024

Source: compiled by the authors based on Structure of local... (n.d.), Local taxes and... (n.d.)

Furthermore, an important component of financial support is capital expenditure, which reflects the investment potential of communities. According to data from 2024, the average amount of capital expenditures per capita in a territorial community was 2,075.8 UAH, which makes it possible to estimate the average amount of investment of 15-16 million UAH per community per year. These funds are used to develop infrastructure, education, healthcare, culture and sports, forming the basis for long-term growth (Decentralisation, 2025b).

Notably, many rural communities actively attract extra-budgetary resources. In 2024, more than 5,000 entrepreneurs, many of them from the agricultural sector, received loans under the "Affordable Loans" programme (Privatbank, n.d.) totalling over 20 billion UAH (Propozitsiya, 2024). This government initiative aims to facilitate access to finance for small and medium-sized businesses on favourable terms, for machinery upgrades, equipment purchases, and processing development, which is crucial for the agricultural sector of the economy in the face of limited solvency. Some grant programmes are also substantial in strengthening the financial capacity of rural communities. For instance, a project by the Research Institute of Organic Agriculture (FiBL, Switzerland) in partnership with SAFOSO AG (Switzerland) (SAFOSO, n.d.) aims to develop organic production, biosafety, and certification, enabling communities to implement environmentally sound practices and enter international markets. In addition, USAID-funded programmes implemented by Kimoniks International (n.d.) provide grants to communities for projects to increase economic resilience, energy efficiency, social entrepreneurship, and local infrastructure. Funding ranges from 100 to 400 thousand euros, which can be used for the implementation of medium-sized projects, creation of new jobs, diversification of the local economy, and involvement of women and youth in entrepreneurial activities (Kurkul, 2024).

In 2023-2024, several rural communities in Ukraine successfully attracted grant support for the development of agricultural production, small businesses and social initiatives. Communities in Zhytomyr, Kyiv, Mykolaiv, and Chernihiv regions became participants in the TalentA programme (Corteva, n.d.), 2024-2025, implemented by Corteva Agriculture. As part of this initiative, women farmers received grants to develop agricultural processing, which was used to start businesses or expand existing small-scale production. One example is the Mykhailo-Kotsiubynske Village Council in Chernihiv region, which, thanks to the programme's support, has set up a grain processing workshop that provides added value and new jobs in the community (European Business Association, 2025).

Another example is the Bilenkivska community in the Zaporizhzhia region, where more than 200 families received financial support for agriculture from the Caritas Zaporizhzhia charitable foundation. The grants contributed to strengthening food security, household development, and stabilising the economic situation in the region (Gubina & Pasichnyk, 2024). In addition, the Myronivsky Hliboproduct Charitable Foundation (MHP) is an active grant-making organisation that has implemented hundreds of projects in rural communities in Cherkasy, Kyiv, and other regions. Its initiatives include supporting small businesses, developing environmental projects, social services, and local initiatives (MHP. Hromadi Charitable..., n.d.). The foundation implemented a microgrant competition "Village. Steps to Development", which since 2016 has helped more than 300 people start businesses in rural areas, providing grant support worth over 16 million UAH (MHP (company), n.d.). Thus, grant support has become an important source of resources for rural communities, contributing to economic revitalisation, increased employment and improved quality of life at the local level. Thus, financial support is not only a tool for covering current needs, but also a strategic basis for planning, attracting investment and achieving long-term goals. Its effective management determines the level of socio-economic development, the quality of life of the population and the ability of communities to function independently in a changing environment.

G. Christmann *et al.* (2024) presented rural development as a result of social innovations initiated from below. Using examples of communities in Germany, Ireland, and Portugal, the

study demonstrated how the creation of cooperatives, digital services, and other initiatives strengthened the autonomy and cohesion of the local population. In contrast, the current study demonstrated how communities strengthen their positions through financial mobilisation of tax revenue growth, grant mobilisation, and effective management of capital expenditures. Both approaches are different, but they convincingly confirm that the active position of the communities themselves is the driver of change.

J.T. Undurraga & B. Pokorny (2024) conducted a systematic review of the literature on the impact of context on rural development in tropical Latin America. The study classified five groups of factors ranging from infrastructure to the environment and showed that the impact of change is not unambiguously positive. The current study also emphasised the role of context but was limited to economic and financial indicators. While J.T. Undurraga & B. Pokorny conducted a generalised analytical framework based on hundreds of sources, this case study captured specific results in community budget management. A completely different focus was demonstrated by A. Steinführer *et al.* (2024) in an analysis of the change in migration trends in Germany from moving to large cities to returning to rural areas. The study determined that the key factors behind such decisions are housing affordability, family ties, and fatigue from urban stress. The current study, on the other hand, emphasises not migration, but the growth of economic autonomy in rural communities. Despite the different focus, both studies documented a reassessment of the value of rural areas in both subjective household decisions and financial management outcomes.

Financial support is a key condition for the sustainable development of rural communities. Due to the growth of internal revenues, active attraction of grants, investments and state support, communities are gradually strengthening their financial capacity even in times of crisis. Analysis of the dynamics of budget indicators and comparison with international studies confirmed that it is the ability to effectively mobilise and use resources, adapting to the context, that determines the level of socio-economic sustainability of communities.

Assessment of the current state of financial support for rural communities in Ukraine

In 2024, the structure of local taxes in rural territorial communities continued to demonstrate a strong dependence on two main sources of the single tax and land fees. In particular, the share of the single tax was about 55-56% of all local taxes and fees, which demonstrated the key role in generating internal revenues for rural communities. Compared to 2019-2023, this figure increased, indicating that small businesses in rural areas were becoming more active. Land payments were second at around 34-35%, which was a decrease compared to 2019, when their share exceeded 44%. This may have been due to a decrease in the amount of land under cultivation or adjustments to the normative monetary value. Other taxes had an insignificant share: rent was less than 5%, and tourist tax was no more than 1-2%, and was applied mainly in communities with developed recreational potential (Decentralisation, 2024a).

The average amount of local tax and fee revenues per capita in rural communities varied significantly depending on the size of the community. In small communities with a population of up to 5,000 people, this figure reached approximately 2,576 UAH, and in some cases exceeded 3,000 UAH. This was determined by the greater concentration of the tax base and the relatively smaller number of residents among whom tax revenues were distributed. In large rural communities with a population of more than 15,000 people, on the contrary, the tax capacity was lower, ranging from 1,600 to 1,700 UAH per person, despite the recorded growth of own revenues by 6.7%. For comparison, in urban communities of similar size, the average level of tax revenues in 2024 was about 1,580 UAH per capita. Thus, small rural communities proved to be more tax-capable than urban ones. The leaders among the communities in terms of internal revenues were the communities of Kyiv region, in particular Prystolichna, Borshchahivska and Kozynska, which demonstrated the highest financial indicators per capita. For example, in 2024, the total budget of the Prystolytska rural territorial community amounted to 804.5 million UAH, of which 789.96 million UAH was accounted for by the general fund and

14.52 million UAH by the special fund. The general fund surplus amounted to 161 million UAH, with expenditures of 628.95 million UAH. Special fund expenditures amounted to 175.53 million UAH, the reserve fund to 3 million UAH, and the budgetary revolving balance to 2 million UAH Borshchahivska rural territorial community saw a significant increase in personal income tax (PIT) revenues, which indicates high economic activity of both households and businesses. This confirms the stable budgetary capacity and the ability of these communities to effectively provide development funding. (Local budgets – 2024, 2024).

Interbudgetary transfers played an important role in the structure of rural budget revenues. In 2022, due to the full-scale war, there was a sharp decline in subsidies and grants, which was due to the redistribution of state budget funds for defence. However, in 2023, their volume increased significantly: rural budgets received about 19 billion UAH, which accounted for more than 38% of all revenues. In 2024, the share of subsidies was 19.0%, and grants were 7.5%, or 26.5% of total revenues. At the same time, the share of transfers in the structure of revenues of rural communities remained at 38%, indicating that they remained heavily dependent on state funding (Decentralisation, 2024b).

The most dependent on transfers were small communities with a low tax base, as well as communities located in the de-occupied or frontline areas. In 2024, there were about 119 territorial communities with a base grant exceeding 50% of general fund revenues. In some cases, this share reached 60-70%. For instance, in the Kochubeyivska community, internal revenues accounted for 65.4%, in the Muzykivska community 48.2%, and in the Stanislavska community 53.6%. This demonstrated a significant variation in the level of budgetary capacity even within the same type of community (Berezyuk, 2024). In 2024, the main share of rural budget expenditures, as in 2022-2023, was spent on social services. About 26-28% of total expenditures (187.1 billion UAH nationwide) were allocated to education, 10-11% to healthcare (approximately 20.9 billion UAH), and 7-8% to social protection (approximately 35.4 billion UAH). Expenditures on housing and communal services, including infrastructure projects, amounted to 8-10%, and on culture, 2-3%. Thus, the priorities remained education, healthcare, basic services, and landscaping (Decentralisation, 2024b).

Capital expenditures, which reflected the investment potential of communities, were of particular importance for assessing development. In 2024, the average share of capital expenditures in the overall structure of the country reached 23.1%. In rural communities, this figure varied from 7% to 12%, with a general upward trend. Per capita, the average amount of capital expenditures in rural communities was 2,075.8 UAH, which indicated an increased focus on infrastructure development even with limited resources. The analysis of the implementation of budgets for 2022-2024 showed the overall resilience of rural communities to economic and security challenges. Total revenues increased from 21.3 billion UAH in 2022 to 27.4 billion UAH in 2024. However, in 2023-2024, some communities, mostly small ones, experienced a 20-35% reduction in revenues. The main reasons for this were a drop-in business activity, internal migration, and a reduction in land use. In contrast, large rural communities demonstrated an increase in internal revenues (Decentralisation, 2025a).

In 2024, revenue targets were met at 95-100% in most rural communities. A similar picture was observed for expenditures, which remained stable, with deviations only in some communities. However, in several territories, typical deviations were recorded, including: a shortfall in tax revenues (especially in the combat zones), an excessive burden on the administrative apparatus (in some communities, its costs reached 80-90% of their revenues), and insufficient use of investment funds due to a lack of project management and organisational resources. Imbalances in tax capacity remained significant. In 2024, the gap between the richest and poorest communities in terms of per capita income reached 250 times. This situation created difficulties in providing basic services in weak communities and required a review of approaches to financial equalisation (Decentralisation, 2025a). Thus, in 2024, rural communities continued to demonstrate resilience, flexibility and adaptability. At the same time, they remained highly dependent on transfers, and internal tax resources remained unevenly

distributed. Further improvement in governance efficiency will require strengthening the tax base, increasing community participation in grant and loan programmes, and improving intergovernmental support mechanisms in the face of uneven regional development.

Compared to the study by M. Karami & R. Madlener (2023), the focus of the current study is different. While the German authors proposed an assessment of the sustainability of rural municipalities through a multidimensional benchmarking system, Ukrainian communities were examined from the perspective of financial mobility in the context of military instability. The justification for the growth of investment potential through loans and grants contrasts with the regional gaps identified by M. Karami & R. Madlener's findings of regional gaps in the technological and environmental dimensions. The difference was not only in the methods, but also in the levels of analysis: in the first case, a strategic assessment of sustainability, in the second, practical support for development through financial instruments.

F. Piras *et al.* (2024) investigated a strategic approach to the allocation of CAP resources among Italian regions. This analytical vector differed from the practice-oriented nature of the current study, which focused on attracting grants and implementing local initiatives. While the Italian regions were classified according to their dominant financial strategies as investment, environmental or mixed, Ukrainian communities demonstrated examples of adaptation to limited conditions by mobilising available sources of funding. A different vision of rural development was proposed by S.A. Ali *et al.* (2024), highlighting the environmental and spatial marginality of areas in Southern Italy. Their analysis focuses on the potential for restoring degraded landscapes and attracting social capital. In contrast, the current study assessed the growth of community capacity through indicators of income, transfers and capital expenditure. The idea of the need for targeted support for rural areas was common to both studies, but it was implemented in different environmental, landscape, and financial and managerial ways.

A. Kallert *et al.* (2021), in their study of rural development in Germany, focused not so much on support instruments as on discursive contradictions. The study described how, in practice, the proclaimed goals of equal living conditions remain unrealisable due to the dominance of neoliberal logic and a chronic lack of funding. Meanwhile, the current study showed an increase in the financial capacity of communities in the dynamics through the analysis of budgets, income structure, and implemented programmes. Thus, if A. Kallert *et al.* criticised the declarative nature and ineffectiveness of the policy, this study illustrated examples of its effectiveness in practical terms. In the case of the study by F. Cisilino *et al.* (2024), the analysis emphasised the micro-level of the effectiveness of agricultural enterprises' participation in integrated food chain projects. Based on statistical data, the study proved the positive impact of such programmes on farm productivity. In contrast, the present study emphasised the financial situation of communities. Both approaches demonstrate that engaging in structured forms of support, whether through Integrated Supply Chain Projects (ISCPs) or government and grant programmes, can improve socio-economic performance, although the levels of analysis were different.

The study by M. Dziamulych (2023) investigated financial security as a key factor in the sustainable development of the region. The mechanisms of financial management and sources of funding that were relevant for ensuring rural development in territorial communities were considered. An assessment of the impact of investments from the European Rural Development Fund by D. Insolda *et al.* (2024) revealed another macroeconomic dimension. The study found positive dynamics in GDP and agricultural production in Italian regions after the European Agricultural Fund for Rural Development (EAFRD), albeit with a certain decline in employment. In contrast, the current study analysed specific indicators of community budgets, their ability to implement capital projects, maintain basic services, and attract external financing. Both studies pointed to the importance of investment, but at different scales – regional and local. The study by L. Briamonte *et al.* (2024) emphasised the social sustainability of the agricultural sector: employment, human rights, and safe working conditions. The study proposed a system of KPIs to assess the social impact of

agricultural production. This perspective differed significantly from the Ukrainian context, where the emphasis was on indicators of financial self-sufficiency of communities. At the same time, both studies were based on the need to formulate reasonable criteria for assessing sustainable development, one in the social plane and the other in the financial plane.

In 2024, Ukraine's rural communities continued to demonstrate their ability to adapt to military and economic instability. A single tax remained the main source of internal revenues, and the share of transfers showed a continued high dependence on state support, especially in small communities and frontline areas. At the same time, there was an upward trend in capital expenditures, indicating a desire to invest in development. The comparison with European studies confirmed the relevance of a local approach to supporting rural development: while Western authors mainly focused on strategic planning, environmentally sustainable transformation, and social impact assessment, Ukrainian practice was based on practical financial mobilisation of resources.

Directions for improving financial support for rural development in the local government system

Financial support for rural development requires not only a review of existing budget planning tools but also a deep rethinking of general approaches to resource management at the local government level. As a result of the decentralisation reform, local governments have been granted much broader powers to manage finances, property, and implement social and economic policies. However, this has also resulted in increased responsibility, for the efficient use of budget funds, ensuring the stability of basic services and the implementation of development programmes. In such circumstances, communities face the need to introduce new financial practices based on the principles of stability, flexibility, transparency and adaptability to changes in the external environment. The successful exercise of powers depends not only on the number of accumulated resources but primarily on the community's ability to strategically manage them, forming an effective and self-sufficient financial policy capable of supporting long-term development.

One of the most pressing challenges for rural communities is ensuring stable access to various sources of funding. In most cases, communities cannot rely solely on revenues from taxes and fees. A low tax base, demographic losses, limited business activity and external risks (war, energy crisis, migration) force local governments to seek additional resources. Therefore, the state support in the form of grants and subsidies, international grants, technical assistance, targeted programmes of partners with the European Union and USAID, social investments by businesses, loans from banks and development funds are substantial in building the financial capacity of rural development. At the same time, innovative approaches, such as raising funds through crowdfunding platforms, issuing social bonds, municipal loans, etc., are gaining relevance. The combination of budgetary and extra-budgetary sources provides flexibility in forming budget revenues, minimises the risks of overdependence on state transfers, and formulates a sustainable basis for implementing strategic priorities.

Efficient administration of local taxes remains one of the most effective tools for increasing own revenues. Optimising the collection of personal income tax, unified tax, and land payments requires the introduction of modern electronic services that simplify interaction with taxpayers, reduce administration costs, and automate processes. The tax base can be expanded by creating a complete register of taxpayers, conducting an inventory of property, digitalising land records, and legalising business activities in rural areas. The high share of the shadow economy remains one of the main threats to sustainable development, and therefore, transparent tax administration mechanisms are not only a technical but also a strategic task for the community. Successful financing of social, educational, and infrastructure projects is impossible without the participation of civil society and the private sector. Involvement of the public in the budget planning decision-making process can be used for consideration of the real needs of residents, increases the legitimacy of management decisions, and stimulates social activity. Business participation in rural development, including

through social partnerships, interest-based philanthropy, patronage, or public-private partnerships, can be used for the implementation of large-scale projects to upgrade infrastructure, build kindergartens, schools, outpatient clinics, sports or cultural facilities. As a result, synergies are formed between public institutions and private initiatives, which contribute to improving the quality of life (Zhang *et al.*, 2024).

Another key element of effective financial management is strategic planning. Communities that develop sustainable development strategies, formulate multi-year investment plans, set clear goals and key performance indicators, usually demonstrate higher performance indicators for the use of funds. One example of a community that actively uses strategic planning is the city of Khmilnyk in Vinnytsia region. In 2019, the Khmilnyk Resort Development Strategy for the period up to 2027 was adopted, which was the result of comprehensive work by local authorities with the support of PLEDDG (The development strategy..., 2019). Forecasting community needs, assessing budgetary risks, and analysing the effectiveness of previous expenditures can be used for a flexible response to changes and minimise losses. The strategy is also an important prerequisite for attracting international funding: donors require a clear development logic, justified priorities, and the community's ability to implement changes. Transparency and accountability have become one of the main standards of modern financial management. Communities that open their budgets to citizens, publish financial reports, and create online platforms for residents to participate in the budget process have a higher level of trust and engagement. Public discussion of budgets, the possibility of submitting initiatives for funding through the participatory budgeting mechanism, and accountability to the community all form a healthy environment for interaction between the government and society (Idris, 2024).

Rationalisation of the expenditure structure mitigates deficits, reduces inefficient spending and reallocates resources to development projects. For instance, reduction of the cost of maintaining a management apparatus, reduction of excessive utility costs, or outsourcing of certain administrative functions provides additional funds to the construction, modernisation of social infrastructure, support of local businesses, or stimulation of youth initiatives. The regulatory and legal aspect requires special attention. The active participation of communities in the development of legislative initiatives, submission of proposals through local government associations, and analysis of the consequences of changes in tax legislation or intergovernmental financing can create a more equitable and functional system of budgetary relations. Incorporating the position of communities in the state regional policy increases the effectiveness of reforms and strengthens the institutional framework for local autonomy (Idris, 2024). Table 1 provides examples of how these areas are already being implemented in the practice of individual communities, demonstrating the effectiveness and replicability of such approaches.

Table 1. Examples of implementation of areas for improving financial support in communities

Direction	Case study
Diversification of financing sources	In 2024, the Bilenkivska community (Zaporizhzhia region) received grant support from the Caritas Zaporizhzhia Charitable Foundation for more than 200 families. This support was provided in the form of grants for agriculture under the Immediate Response to the War in Ukraine project, funded by the Norwegian Agency for Development and Cooperation (NORAD) with the support of Caritas Norway.
Efficient tax administration	The Prystolytska rural community (Kyiv region) implemented a system of electronic land registration and lease legalisation in 2023.
Public and business participation	The Haisyn community (Vinnytsia region) has implemented more than 10 projects with agricultural companies through social agreements in 2022-2024.. The funds were used to develop infrastructure, education, healthcare, and support small businesses. The projects include the purchase of school buses and the reconstruction of medical facilities. This has improved the availability of services and the quality of life for residents. Social agreements have become an effective tool for business and community cooperation.

Table 1, Continued

Direction	Case study
Strategic planning	The Mykhaylo-Kotsiubynska Hromada (Chernihiv region) created a grain processing development plan and attracted a grant in 2023-2024.
Transparency and accountability	The Kozynska community (Kyiv region) introduced an online participatory budgeting platform called E-Democracy in 2021. This platform enables community residents to submit projects, vote for them, and participate in the distribution of participatory budget funds, which promotes transparency and citizen engagement in decision-making.
Cost optimisation	The Ruskopolyanska rural territorial community of Cherkasy region, in the process of optimising local finances, reduced the cost of maintaining the administrative apparatus by 18% in 2024.
Legal and regulatory improvement	The participation of rural communities, through the Association of Ukrainian Cities (AUC), in the drafting of laws on the financing of local governments (LGUs) covered several key initiatives, including the draft State Budget of Ukraine for 2025, as well as draft laws No. 5244-3 and No. 5364 (on the fair transfer of the personal income tax share to local budgets), No. 5651-2 and No. 5651-3 (on compensation for benefits) and No. 11131 (on the restoration of medium-term budget planning at the local level).

Source: compiled by the authors based on Local budgets – 2024 (2024), K. Berezyuk (2024)

The implementation of such approaches shows that communities that use an integrated approach to financing can achieve sustainable development even in conditions of limited resources. In 2025, reliance on classical budget revenues alone will no longer ensure full economic growth, especially in an unstable environment. Instead, a combination of local taxes, state support, international grants, self-financing, and public-private partnerships creates financial flexibility and adaptability. Rural communities that combine managerial responsibility with transparent decision-making mechanisms, engage partners, use new forms of financing, and consistently implement strategic plans have a better chance of success. This model of governance transforms constraints into opportunities, creates development budgets and strengthens the economic base of rural areas.

In the context of fragility, both this study and A. Makhaye & M. Subban (2024) addressed local development issues, but they did so through different lenses. This study demonstrated how communities mobilised resources in crisis conditions, increasing their financial self-sufficiency. The South African study, on the other hand, emphasised the barriers to effective resource management, political pressure and distrust of the authorities. Despite their different scales, both examples confirmed the need for flexibility and local partnerships. Reactions to centralised policies without accompanying funding were explored by Z. Ye *et al.* (2024), comparing them to the practices of Chinese communities. There, local authorities often imitate the implementation of tasks without real tools. This study, on the other hand, demonstrated a real increase in budgetary capacity based on available tax and transfer sources. The study by L. Zhu *et al.* (2024) shifted the focus to the impact of land income distribution on household debt burden in China. It demonstrated a correlation between the share of funds allocated to development and the financial stability of rural families. At the time, the current study focused on the system-wide financial dynamics of communities. Y. Yu *et al.* (2024) explored how rural development can be combined with education and governance in African countries, drawing attention to the lack of coordination and institutional weakness. In contrast, this study pointed to concrete financial improvements in communities that were already actively implementing local initiatives. Both studies emphasised the importance of context, but the Ukrainian case study was empirically based, and the African one was conceptually based.

The study by L.E. Nwaoburu (2024) emphasised the systemic problems of local government in Nigeria: lack of autonomy, ineffective governance, and political interference. In this context, the study demonstrated the practical growth of autonomy even in times of war. There was a common opinion on the importance of financial independence, although in one case, it still needs to be achieved, in the other, it has already been partially implemented. In addition, the study by

K. Muldoon-Smith *et al.* (2023) analysed in depth the financial system of local governments in Germany as an interconnected institutional network with clearly defined principles of subsidiarity and "connectivity". In comparison, the current study reveals significant fiscal inequalities between communities, which are not always compensated for by the current equalisation system. In both cases, the role of the state in strengthening the capacity of communities is at stake, but in different political and governance realities.

Financing rural development in the face of multilevel challenges requires a comprehensive, flexible and strategic approach. Decentralisation has created new opportunities for resource management, but at the same time, increased the responsibility of communities for their effective use. This study has shown that sustainable development of rural areas is possible only if funding sources are diversified, taxes are administered transparently, the public and business are involved, and communities have active strategic planning.

CONCLUSIONS

To summarise the results of the study, it is worth noting that the financial support for rural development in the territorial communities of Ukraine in 2021-2024 has undergone significant changes under the influence of decentralisation, military challenges and economic instability. Despite the difficult circumstances, communities have demonstrated a gradual increase in financial capacity: total revenues increased from 29.0 billion UAH in 2021 to 40.4 billion UAH in 2024, and the average amount of local taxes and fees per capita reached 2,530.6 UAH in 2023, which is higher than the pre-war figure of 2,190.4 UAH in 2021. While in 2024, it reached approximately 8,183 UAH (excluding transfers), according to the analysis of 1,331 communities, the share of internal revenues in the structure of local budget revenues in 2024 reached 46-48%, with the share of personal income tax at 36.3% and local taxes at 12%. At the same time, about 38% of rural budget revenues came from intergovernmental transfers, which indicates a continued high dependence on state support, especially in small or frontline communities, where the basic subsidy in 119 communities exceeded 50% of general fund revenues.

Investment activity also showed positive dynamics: the average amount of capital expenditures per capita in 2024 was 2,075.8 UAH, which enabled communities to implement projects in infrastructure, education, and healthcare. Extra-budgetary resources were noted to be substantial in rural development: in 2024, more than 5,000 entrepreneurs raised more than 20 billion UAH under the Affordable Loans programme, and grant support covered communities in at least six regions, including recycling projects, small business development, and household support.

Comparison with European approaches demonstrated the difference in the Ukrainian context, where the focus is on financial mobilisation and overcoming resource inequalities between communities, with a per capita income gap of 250 times in 2024. As a result, financial flexibility, strategic planning, public participation, and effective administration of local taxes were the main factors of successful development. The limitation of this study is that it focuses exclusively on financial and economic indicators without considering the socio-cultural and environmental factors of rural community development. Prospects for future research include a comprehensive analysis of the relationship between the financial capacity of communities and the quality of life, environmental sustainability, and the level of social cohesion.

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Євгеній Ланченко
Доктор економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0003-0894-4885
Володимир Івченко
Кандидат сільськогосподарських наук, генеральний директор
Український науково-дослідний інститут продуктивності агропромислового комплексу
03035, пл. Солом'янська, 2, м. Київ, Україна
https://orcid.org/0009-0000-2035-2976
Олександр Носіков
Кандидат соціологічних наук, провідний науковий співробітник
Український науково-дослідний інститут продуктивності агропромислового комплексу
03035, пл. Солом'янська, 2, м. Київ, Україна
https://orcid.org/0009-0006-3465-9665

Фінансове забезпечення сільського розвитку в територіальних громадах

Анотація. Метою дослідження було виявити особливості функціонування системи фінансового забезпечення сільських територіальних громад та оцінити її здатність забезпечувати сільський розвиток у контексті нових управлінських та економічних викликів. Методологія дослідження ґрунтувалася на аналізі динаміки доходів сільських територіальних громад за 2021-2024 роки, структури доходів місцевих бюджетів, капітальних видатків та позабюджетного фінансування. У результаті дослідження встановлено, що загальний обсяг доходів сільських громад зріс з 29,0 млрд грн у 2021 році до 40,4 млрд грн у 2024 році. У 2023 році середній обсяг надходжень місцевих податків і зборів на одного мешканця сягнув 2530,6 грн, що перевищило показник 2021 року (2190,4 грн), а за даними аналізу 1331 громади у 2024 році він становив приблизно 8183 грн (без урахування трансфертів). Основну частку доходів у 2024 році становив податок на доходи фізичних осіб (36,3 %) та місцеві податки (12 %), тоді як частка міжбюджетних трансфертів залишалася високою – близько 38 %. Також зафіксовано зростання капітальних видатків: у 2024 році середній обсяг таких видатків становив 2075,8 грн на одного мешканця. Позабюджетні ресурси відігравали важливу роль: понад 5000 підприємців отримали кредити на суму понад 20 млрд грн, реалізовано десятки грантових проєктів у громадах щонайменше шести областей. Висновки дослідження підтвердили, що фінансова гнучкість, стратегічне планування, ефективне адміністрування місцевих податків і залучення зовнішніх ресурсів є ключовими чинниками стабільного розвитку сільських громад навіть в умовах кризи. Результати дослідження можуть бути використані органами місцевого самоврядування для вдосконалення механізмів бюджетного планування, підвищення фінансової самостійності громад та залучення додаткових ресурсів для сталого розвитку сільських територій

Ключові слова: інвестиція; доходи; податок; бюджет; стратегічне планування; розвиток сільських територій; підприємництво

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Viktoriia Kostiuk*
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0001-7671-3603

Oleksii Muravskyi
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-7117-7335

Lidiia Avramchuk
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-7496-0392

Vitaliy Lutsenko
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0009-0009-6177-1806

Ghenadie Ciobanu
Doctor of Economics, Senior Research
National Scientific Research Institute of Labour and Social Protections
010643, 6-8 Povernei Str., Bucharest, Romania
Artifex University of Bucharest
060754, 47 Economu Cezărescu Str., Bucharest, Romania
https://orcid.org/0000-0002-2361-9717

Evolution of digital banking services in Ukraine: Impact on business development and financial infrastructure

Abstract. The research relevance is determined by the rapid digitalisation of Ukraine's financial sector and the need to provide small and medium-sized businesses with effective tools for accessing finance in the context of economic transformation. The study aimed to assess the impact of digital

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*Corresponding author

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banking services on SMEs' access to finance in Ukraine. For this purpose, a comprehensive analysis of the regulatory framework, statistical data on the share of non-cash transactions, the activity of financial technology companies, and digitalisation trends in the banking sector was conducted. An analysis of statistics for 2023-2024 showed that the share of non-cash transactions with payment cards reached 94.6% by number, and the total number of such transactions was 8.65 billion in 2024. The number of identifications through the NBU's BankID system more than doubled from 42.9 million in 2023 to 87.7 million in 2024. The mobile apps of the largest banks, including Monobank and Privat24, were downloaded more than 10 million times each in 2024. In 2024, entrepreneurs received more than 16,000 loans worth more than 62 billion UAH under the Affordable Loans 5-7-9% programme. In 2025, the level of digitalisation of banking services for business in the regions of Ukraine will exceed 80%. These results indicate a deep integration of digital banking services into the financial activities of small and medium-sized businesses, a significant increase in access to financial resources, and a significant increase in financial inclusion. The practical significance of the study is the creation of a framework for improving the digital financial infrastructure, which will contribute to the further development and increase the availability of financing for small and medium-sized businesses in Ukraine

Keywords: digital banking; financial technology; digital transformation; online banking; mobile banking; blockchain

INTRODUCTION

The digital transformation of banking services is becoming key to building an efficient financial system, supporting business activity and modernising market infrastructure. This issue is particularly relevant for Ukraine, which is facing both global and domestic challenges: technological breakthroughs, the effects of military operations, economic restructuring, and the need for transparent and affordable financial mechanisms to support small and medium-sized businesses. In these circumstances, digital banking services are becoming a central link in ensuring the continuity of financial flows, expanding access to capital, and increasing the financial inclusion of the population and entrepreneurs.

The development of the Ukrainian financial system is accompanied by the rapid spread of digital technologies, which is leading to fundamental changes in the way banking services are delivered, through the growing role of mobile and digital banking, remote banking and digital platforms. N. Danik & A. Torlopov (2024) showed that mobile platforms, cooperation with financial technology (FinTech) companies, process automation, and personalisation of services increase the efficiency of banks. The authors also highlighted the growing role of cybersecurity and new staff competencies. The proliferation of digital services in the banking sector necessitates an updated customer service system and a revision of approaches to financial transaction management. T. Staverska & Y. Litvinova (2024) examined the mechanisms for improving the efficiency of banking activities in the context of digitalisation, particularly the impact of online services, electronic document management and automation on simplifying procedures and reducing costs. The study also noted the increasing role of omnichannel services and individualisation of financial solutions, which form a new quality of bank-client interaction.

Digital technologies are radically changing approaches to banking, necessitating the adaptation of traditional financial institutions to new market conditions. A. Meshcheriakov *et al.* (2023) studied the impact of digital tools on the transformation of banking processes, focusing on the development of remote services, the use of artificial intelligence, and the integration of financial technology FinTech solutions. The study identified the main benefits of digitalisation, including increased efficiency, reduced costs, and increased customer focus. The active digitalisation of the banking sector is occurring in the context of economic instability, which requires adaptation to new challenges and revision of development strategies. M. Shevchenko *et al.* (2023) studied the dynamics of the

digital transformation of Ukrainian banks, focusing on adaptation to crisis circumstances, changing approaches to risk management, and the introduction of innovative technologies. The authors emphasised that digital solutions ensure continuity of customer service, increase the level of remote interaction, and reduce dependence on physical infrastructure.

The challenges of digital transformation in the financial sector require active improvement of management tools and interaction between banks and customers. Y. Khudolii & A. Hlushko (2023) studied the main stages of development of digital banking services in Ukraine, focusing on the benefits of remote banking, reduction of transaction costs, and increased financial inclusion. The study also emphasised the importance of digital tools for empowering banks in times of economic instability and military operations. The rapid adoption of digital services in the banking sector is leading to a transformation of approaches to organising financial transactions, customer service and the formation of a new structure of financial interaction. Y. Verheliuk *et al.* (2025) studied the impact of digitalisation on banks' development strategies, emphasising the growing role of FinTech services, increased productivity through automation, and the expansion of e-service channels. The study also highlighted the need to harmonise regulatory mechanisms with digital trends. The intensive introduction of digital solutions into the banking environment is transforming financial interactions, requiring new management approaches and infrastructure adaptation. A. Semenog *et al.* (2024) analysed the development of digital financial technologies in Ukraine, focusing on digital banking tools, digital platforms for customer service, and the effectiveness of implemented services. The study noted the positive impact of digitalisation on reducing costs, increasing transparency of operations and improving customer experience.

Despite active research on the digitalisation of the banking system, the impact of digital services on entrepreneurship remains insufficiently covered, in terms of access to finance for small and medium-sized businesses, the efficiency of innovative banking instruments, the development of new models of interaction with financial institutions, and the participation of non-banks in financial inclusion. These aspects require a systematic analysis to describe their role in supporting business activity and the long-term sustainability of the financial infrastructure. The study aimed to determine how digital banking services affect the ability of small and medium-sized businesses to obtain financing in Ukraine. To achieve this goal, the following objectives were set: to analyse the stages of digitalisation in the banking sector of Ukraine; to assess changes in financial accessibility for entrepreneurs in the context of digitalisation of banking services.

MATERIALS AND METHODS

This study was practical and covered the period from 2019 to February 2025. It defined the role of digital banking services and their types based on the research of A.A. Mohammed (2024) and N. Mujtaba & A. Yuille (2024). These sources were chosen due to their relevance, depth, and comprehensiveness in covering technological trends in digital financial services, in the areas of security, automation, and innovative payment solutions, which are substantial for the transformation of banking processes. The study of the regulatory framework included an analysis of key documents, such as the Law of Ukraine No. 675-VIII (2015), which lays down the fundamental legal framework for the use of electronic contracts, electronic signatures and remote user identification. The authors also took into account Resolution No. 43 (Board of the National Bank of..., 2014), which regulates the procedure for registration of payment systems and payment infrastructure operators, as well as the Regulation on Electronic Money (Resolution No. 481) (Resolution of the Board of the National Bank of Ukraine No. 178, 2008), which regulates the issuance and circulation of electronic money in Ukraine. The Law of Ukraine "On Payment Services" No. 1591-IX (State Tax Service of Ukraine, 2023), which implements European directives and defines the legal status of new market participants, in particular FinTech companies and non-bank payment service providers, as well as lays the foundation for the concept of open banking and further development, is also considered separately.

The share of non-cash transactions in 2023-2024 was analysed (National Bank of Ukraine, 2025a), as well as the dynamics of the use of the BankID electronic identification system of the National Bank of Ukraine (NBU) (Ukrinform, 2025). Particular attention is paid to the number of transactions using payment cards (Interfax-Ukraine, 2025). The study examined the dynamics of FinTech companies in 2022-2024 and the introduction of relevant technologies (National Bank of Ukraine, 2024b), which was analysed using descriptive statistics and monitoring of changes in this area. An analysis of the statistics on the use of online banking and digital platforms by entrepreneurs was developed. The percentage of use of mobile applications and digital banking was analysed. An analysis of the statistics on the use of online banking and digital platforms by entrepreneurs from 2019 to 2024 was developed using data from Privatbank (n.d.), Oschadbank (n.d.) and Monobank (n.d.). To assess trends, methods of dynamic analysis and comparative analysis of user activity were used. The number of loans received by entrepreneurs in 2024 under the "Affordable Loans 5-7-9%" programme was estimated (PrivatBank is a participant..., n.d.; Ministry of Economy of Ukraine, 2025). A comparison of digital services for small business lending at PrivatBank, Monobank, and FUIB was developed (Pumb, n.d.) using content analysis of the functionality of mobile applications and platforms, as well as integration with accounting and CRM systems. Barriers to entrepreneurs' access to digital banking products were also identified. The participation of non-banks in the formation of the digital financial ecosystem and ways to improve the efficiency of small businesses' use of digital services, which has become a substantial aspect of the study in the context of the development of innovative financial technologies and ensuring broad access to financial resources for sustainable development, were addressed.

RESULTS AND DISCUSSION

Transformation of banking services under the influence of digitalisation: Conceptual and regulatory frameworks

Digital banking services are a set of financial transactions provided by banking institutions using information technology, without the need for a customer's physical presence in a branch. Their development reflects the general trend towards digitalisation of the financial sector, focused on convenience, speed, personalisation and reduction of transaction costs. Digital banking services are based on Internet banking, mobile banking, e-wallets, virtual cards, automated customer identification systems, and artificial intelligence services. The introduction of such services optimises internal processes, reduces the burden on physical branches, improves the quality of customer service, and expands market coverage (Ranjan, 2024).

The most common types of digital banking services include digital banking, which is the remote management of accounts through bank web portals and provides access to basic financial transactions: transfers, bill payments, opening deposits, monitoring balance and transaction history. In parallel, mobile banking is actively developing, providing similar functionality through mobile applications. Thanks to the active use of smartphones, mobile applications have become the main channel of banking services for small businesses, providing quick and convenient access to financial transactions without visiting the office (Feyen *et al.*, 2021). Electronic payment instruments, such as e-wallets, virtual bank cards, Quick Response (QR) codes, and contactless payments, are a separate area of digital banking services. Their use simplify the process of paying for goods and services, increasing the speed of service, and reducing operating costs for businesses. The latest digital banking tools include the open banking concept, which can be used by third-party developers to integrate banking services into their platforms via APIs (application programming interfaces). This creates new business opportunities, particularly in the areas of financial planning, reporting and accounting automation (Mohammed, 2024).

The development of digital technologies in Ukraine's banking sector has gone through several key stages, reflecting the gradual transformation of the industry and its adaptation to modern challenges. Until 2015, basic digital services were being developed, including the first internet banking platforms and electronic payment systems. During this period, banks

began to introduce remote customer service, but large-scale digitalisation was limited due to technical barriers and low digital literacy among users. In 2015-2019, there was an active expansion of the functionality of digital platforms and the development of mobile banking. The first financial technology companies (FinTechs) emerged, and the regulatory framework began to adapt to the needs of digitalisation, stimulating the introduction of new digital products and services. Banks have significantly improved the availability of their services through mobile applications, which has helped to increase customer outreach. In 2020-2022, the number of online transactions increased rapidly, driven not only by technological developments but also by the challenges of the COVID-19 pandemic. In the first six months of COVID-19 alone, the number of transactions within open banking increased by 832% During this period, artificial intelligence, process automation and remote customer identification technologies were widely implemented, through the Bank Identification (BankID) system. Digital platforms have become the main channel of interaction between banks and customers, ensuring continuity of service and increasing operational efficiency. Since 2023, the financial sector has been undergoing a systemic transformation, including the introduction of integrated digital ecosystems, harmonisation of the regulatory framework with European standards, development of open banking, and strengthening of cybersecurity. Special attention is paid to increasing financial inclusion and expanding access to digital banking products for small and medium-sized businesses. This stage forms the basis for a sustainable and innovative financial infrastructure capable of meeting modern economic challenges (Demchyshak *et al.*, 2024).

A substantial area of innovation is the use of artificial intelligence and data analytics in banking. Machine learning algorithms are used to personalise offers, detect fraudulent transactions, assess credit risk, and automate customer service through chatbots. For entrepreneurs, such tools accelerate financing decisions, better describe their solvency, and provide individualised recommendations. The Law of Ukraine No. 675-VIII (2015), which lays down the legal framework for the use of electronic contracts, electronic signatures and remote identification of business entities, is substantial in shaping the regulatory framework for digital financial services. In this context, the BankID system from the National Bank of Ukraine is key, providing legally significant customer verification in the digital environment. Its implementation provide entrepreneurs, in particular small and medium-sized businesses, with access to banking and public services without physical presence, which significantly reduces transaction costs and increases financial inclusion. Digital banking services are gradually integrating new customer identification formats, including remote verification via BankID, video identification and the use of biometric data. These mechanisms simplify the creation of bank accounts, submitting loan applications, and participating in financial programmes. At the level of by-laws, the NBU has adopted several regulations, including the Regulation on the Procedure for Registration of Payment Systems, Payment Infrastructure Service Operators and Postal Service Operators (Resolution No. 43) (Board of the National Bank of..., 2014), the Regulation on Electronic Money (Resolution No. 481) (Resolution of the Board of the National Bank of Ukraine No. 178, 2008), as well as regulations on cybersecurity and personal data protection in the digital environment. Such a regulatory framework helps to increase business confidence in digital financial products, creating the preconditions for their active use in the context of the digital transformation of the economy (Mujtaba & Yuille, 2024).

In the context of the NBU's growing role as a key institutional driver of the digital transformation of the financial sector, the issue of regulatory support for these processes is of relevance. The NBU's institutional support not only stimulates the implementation of innovative solutions in the banking sector but also creates a favourable regulatory environment for the development of digital financial services. Changes in the regulatory framework directly contribute to expanding access to modern financial instruments for small and medium-sized businesses (SMEs), which in turn improves financial inclusion and increases the efficiency of business processes.

The regulatory framework for digital financial services for business in Ukraine is being developed in the context of the overall strategy of digital transformation of the financial sector, which is a priority for the National Bank of Ukraine and the government. The basis of legal regulation is the Law of Ukraine "On Payment Services" No. 1591-IX, which came into force in 2021 and is gradually being implemented (State Tax Service of Ukraine, 2023). This law implements the main provisions of the European Union (EU) Directive PSD2 (Payment Services Directive 2) (European Central Bank, 2018) and defines the legal status of new market participants such as non-bank payment service providers, FinTech companies, e-money and digital wallets. The law provides for the principle of open banking, which ensures access to third-party services to the banking infrastructure with the client's permission, and forms the basis for the development of new models of interaction between businesses and financial institutions through APIs. In addition, Ukraine is a party to the Association Agreement between Ukraine and the EU (Association Agreement between Ukraine..., 2018), which provides for the harmonisation of national financial legislation with European standards. This leads to Ukraine's integration into Europe's digital single market and opens additional opportunities for exporting FinTech services, scaling digital services, and attracting international investors (National Bank of Ukraine, 2024a). The practical consequence of these regulatory changes is the active implementation of digital services, which are of particular importance for small and medium-sized businesses. The most popular solution among entrepreneurs is mobile lending, which provides quick financing without the need to visit bank branches. For example, PrivatBank has launched a programme of lending for Ukrainian machinery with state compensation of 15% of the cost, where the minimum loan amount is 240 thousand UAH and the interest rate starts at 7% per annum. This makes lending more affordable and faster for SMEs (PrivatBank launches a new..., n.d.) Electronic reporting, which greatly simplifies tax compliance and reduces administrative burden, and integration with accounting platforms, which automates accounting and provides timely control of financial flows. These tools help SMEs reduce operating costs, improve business management efficiency and respond more quickly to market changes. In addition, the Affordable Loans 5-7-9% programme in 2025 attracted more than 5 billion UAH in loans for businesses in high-risk areas of war, and average monthly lending volumes more than doubled (Ministry of Economy of Ukraine, 2025).

In 2024, the share of non-cash transactions by number reached 94.6% of the total volume of payment card transactions, and by value 51%. Payments in the retail network accounted for the largest share by number of transactions (73.4%), while card-to-card transfers (31.1%) and online payments (14.7%) prevailed by value. This structure of non-cash transactions indicates a high level of integration of digital payment instruments into the everyday financial behaviour of households and businesses (National Bank of Ukraine, 2025a). A significant indicator of digital integration is the dynamics of the use of the NBU's BankID electronic identification system. In 2023, 42.9 million successful identifications were recorded, while in 2024 this figure rose to 87.7 million, an increase of 104%. Most calls (over 81 million) were made by non-commercial subscribers (public services, including the Diia portal (Diia, n.d.)), and the rest by financial institutions. This indicates that BankID is actively involved in the national digital ecosystem. The NBU's stimulation of mobile banking development is also marked by positive dynamics (Ukrinform, 2025). In 2024, the number of transactions using payment cards totalled 8.65 billion, of which the majority were non-cash. The structure of customer service is dominated by the remote format: as of the beginning of 2024, the number of payment service users reached 82 million, of which a significant share (over 79% of individuals and 89% of legal entities) were served online. At the same time, the popularity of banks' mobile applications continues to grow, with Monobank (Monobank, n.d.) and Privat24 (Privatbank, n.d.) apps reaching over 10 million downloads each in 2024 (Interfax-Ukraine, 2025).

Another strategic direction of digitalisation is to support innovation within the so-called "regulatory sandbox". This tool can be used to test financial technologies in a controlled

environment without regulatory risks. In 2024, 256 FinTech companies were operating in Ukraine, which is 10 more than in 2023. Between 2022 and 2024, 17 new companies entered the market (AIN, 2023). According to the Ukrainian Association of FinTech and Innovative Companies, 75% of FinTech companies have already reached the break-even point, which confirms the effectiveness of the NBU's regulatory support. In addition, the NBU encourages the introduction of payment instruments such as QR codes and Near Field Communication (NFC) (Apple Pay, Google Pay) (AIN, 2023). In 2023, the share of non-cash transactions was 91.9%, which was accompanied by the active use of contactless terminals (449.5 thousand, of which 99.2% supported NFC). In 2024, the number of payment card transactions increased to 8.65 billion, and a significant portion of them were made using contactless technologies (National Bank of Ukraine, 2024b).

The study by P.T.T. Tran *et al.* (2023) analysed how digital banking services affect customer loyalty in Vietnam. In contrast, the current analysis considered digitalisation as a tool for improving access to finance in the context of banking sector transformation. A common thread in both papers was the recognition of the importance of mobile banking, online lending, and digital service channels. However, the approach of P.T.T. Tran *et al.* was behavioural, focusing on customer expectations, while this study addressed regulatory changes, open banking infrastructure, and practical cases of digital interaction. S.S. Ashurova & M.F. Meyliyeva (2025) presented a conceptual vision of digital banking in Uzbekistan, focusing on its evolution, government strategies, and international experience. In contrast, the current study is more applied in nature, analysing the direct impact of digital services on users' financial behaviour. Common to both sources is the focus on aspects such as cybersecurity, institutional support for digitalisation, and FinTech integration. At the same time, S.S. Ashurova & M.F. Meyliyeva addressed mainly at the macro level, while the second study was based on the analysis of specific digital tools and statistical data. A completely different perspective was presented in the study by A. Panagariya (2022), which focused on the link between financial reforms and economic growth in India. While both studies recognise the importance of a well-developed financial infrastructure for stimulating the economy, the approach of A. Panagariya's approach focuses on macroeconomic indicators and policy mechanisms, while this context focuses on digital platforms.

The similarity of the thematic guidelines is present in the study of T. Onunka *et al.* (2023) on the impact of digital financial services in Nigeria. The study addressed field data and user satisfaction with digital products. In contrast, the current study was based on the regulatory framework, the dynamics of online transactions, and the impact of government initiatives, which provides a broader perspective on digital transformation through the lens of policy and institutional development.

Digital banking services have become a substantial element of financial sector transformation, providing convenience, speed and accessibility to users. In Ukraine, the development of such services is supported by the NBU through regulatory frameworks, identification systems and innovative tools. The growing share of non-cash transactions and the popularity of mobile banking indicate a deep digital integration of financial services. These results confirm the effectiveness of digitalisation as a means of increasing financial inclusion and modernising banking processes.

Assessing the impact of digital banking instruments on access to finance for small and medium-sized enterprises

Amidst economic instability and growing demand for the efficiency of financial transactions, online banking has become one of the key tools for ensuring the flexibility, accessibility and continuity of businesses' financial activities. For small and medium-sized businesses, digital banking services are critical in minimising time and transaction costs, making payments, obtaining financing, keeping records and communicating with government platforms without a physical presence. In 2025, FUIB (Pumb, n.d.) became the leader in online lending to entrepreneurs, having issued loans to individual entrepreneurs (IEs) in the amount of over 1.2 billion UAH. More than 3,000 entrepreneurs have used this

service, which demonstrates the popularity of remote lending (MinFinMedia, 2025). In the FinTech sector, more than 35,000 entrepreneurs have opened accounts with NovaPay digital bank (NovaPay, n.d.). Overall, 67% of entrepreneurs in Ukraine use digital channels for sales, which indirectly confirms the high level of digitalisation of financial services (Kazantsev, 2025).

Among all cardholders in Ukraine, 94% use digital banking, and 75% use mobile applications. About 51% of Ukrainians are ready to completely switch to digital banking services without physically visiting branches. This indicates that the digital transformation of banking services has become widespread among entrepreneurs (Zhiriy, 2023). From 2019 to 2024, the number of active users of digital banking services in Ukraine changed: a decrease at PrivatBank (-44%) and Oschadbank (-55.1%) contrasts with explosive growth at Monobank (944%), indicating a shift towards mobile services. In 2024, about 80% of individuals managed their bank accounts remotely via internet banking and mobile apps, whereas in 2019, only half of authorisations were made via mobile apps (Privatbank is the best Ukrainian digital..., n.d.; Slesaruk, 2021).

In 2024, Ukrainian entrepreneurs received 16,656 loans worth 62.2 billion UAH under the Affordable Loans 5-7-9% programme (PrivatBank is a participant..., n.d.), and since its launch, more than 95,600 loans worth 329 billion UAH have been disbursed. Of loans, 16.5% are provided online, through PrivatBank and NovaPay, which in 2024 issued loans to businesses worth over 281 million UAH. The share of small and medium-sized enterprises (SMEs) in the UAH loan portfolio increased to 60.2%, and up to 70% of new business loans are granted to SMEs. It is estimated that more than 50% of such lending takes place through digital channels (Ministry of Economy of Ukraine, 2024). In 2024, the NBU's BankID system recorded 5.8 million successful identifications of commercial subscribers, of which more than 5.1 million were for financial services. This demonstrates the widespread use of electronic identification to access digital services. By the beginning of 2025, 39 identifier subscribers and 110 service providers were registered in the system, including 96 commercial organisations (National Bank of Ukraine, 2025b).

According to the research by Y. Tarasovsky (2025), the highest level of digitalisation of banking services for business is observed in Dnipropetrovs'k, Lviv, and Ternopil regions, which scored 43, 43, and 42 points, respectively, in the Digital Transformation of Regions Index 2025. The lowest scores are typical for rural and less urbanised regions with limited digital infrastructure, including Chernihiv, Kherson, and Zakarpattia regions, which have low high-speed internet coverage and limited availability of modern mobile technologies. However, leading banks provide access to digital services for SMEs across the country.

In 2025, 63% of Ukrainians will use mobile payments via digital wallets or QR codes, and 76% will transfer money via mobile banking apps. At the same time, more than 80% of e-commerce transactions are paid for digitally. According to Mastercard, 37% of users use mobile wallets for contactless payments, which is also common among entrepreneurs (All Retail, n.d.).

In the context of the digitalisation of the banking sector in the 2020s, small business lending practices are taking on a new format, with mobile applications and online services being key. Banks such as Privatbank, Monobank, and FUIB have been particularly active in this area, offering entrepreneurs a full range of digital solutions from opening an account to obtaining a loan without visiting a branch. Privatbank offers a separate Privat24 for Business app designed for individual entrepreneurs and legal entities. Its functionality includes account management, payments, tax payments, currency sales, loans and deposits, and delegation of access to accounts (Which bank should an entrepreneur..., n.d.). A significant advantage is the integration with accounting systems such as Bookkeeper (Bookkeeper, n.d.) and Planfix (Planfix, n.d.a), which provide automated accounting and financial control. In addition, the application supports SmartID for electronic signatures, which simplifies the signing of documents (Bookkeeper SaaS, n.d.). Monobank, being a fully digital bank, implements business functions in its main application. It can be used to open accounts for individual entrepreneurs, make payments, obtain loans, and integrate with tax

services. A substantial feature is the availability of online acquiring and the Base service for accepting payments, which is relevant for microbusinesses. Monobank focuses on speed and simplicity, although it does not have a separate app for business (Planfix, n.d.b). FUIB is also actively developing digital services for entrepreneurs. Their mobile application can be used to open accounts, make payments, apply for loans, use electronic signatures, and for integration with Customer Relationship Management (CRM) and accounting systems via the Representational State Transfer Application Programming Interface (REST API). This approach ensures flexible financial and reporting management (Which bank should an entrepreneur..., n.d.).

All three banks, Privatbank, Monobank and FUIB, participate in the government programme "Affordable loans 5-7-9%" and offer a fully online application process. Privatbank provides loans of up to 50 million UAH for up to 5 years at an interest rate of 5% with the possibility of a reduction for job creation ("Affordable loans 5-7-9%..., 2024"). Similar terms are offered by Monobank and FUIB, ensuring fast processing of applications and minimal bureaucracy. Digital loans without collateral account for a significant share of the portfolios of all three banks. Privatbank actively uses microloans and credit cards with grace periods; Monobank offers unsecured loans for individual entrepreneurs with a minimum package of documents; FUIB offers unsecured loans with processing within 24 hours. The average amount of online loans varies: in 2022-2023, Privatbank's loan amounts increased to 1.4-1.6 million UAH, Monobank's amounts mostly do not exceed several hundred thousand hryvnias, and FUIB's loan limits can reach 5 million UAH, although average values are not published (Zaihrayev, 2023). Table 1 provides a visual assessment of the advantages of each bank in digital services for small businesses.

Table 1. Comparison of digital services for small business lending in Privatbank, Monobank and FUIB for 2022-2023

Bank	Mobile application	Online lending	Bookkeeping integration	API/CRM	Average loan sum
Privatbank	Privat24 for business	Yes	Bookkeeper, Planfix	Yes	1.4-1.6 million UAH
Monobank	General application	Yes	Bookkeeper, Planfix	Yes	Up to 0.5 million UAH
PUMB	General application	Yes	REST API	Yes	Up to 5 million UAH (assessment)

Note: API/CRM – Application Programming Interface/Customer Relationship Management
Source: compiled by the authors based on E. Zaihrayev (2023), Planfix (n.d.b), Bookkeeper SaaS (n.d.)

Thus, the digital services of the three banks demonstrate a high level of availability of credit resources for small businesses, simplifying financial interaction through mobile platforms, automation and integration with accounting systems. This helps strengthen the business environment and increase confidence in digital banking as a reliable tool for business development. Digital financial services in the context of developing countries were analysed by J.C. Acosta-Prado *et al.* (2024) through the prism of behavioural barriers, digital literacy, and the level of trust of microentrepreneurs in innovation. Their emphasis on empirical methods revealed the extent to which access to digital platforms is determined by human factors rather than infrastructure. In contrast, this study focuses on comparing digital services for small business lending. A different perspective is demonstrated by G.V. Radhakrishnan & U. Shankar (2024), where digital services were evaluated through the prism of customer experience in India. The study highlighted satisfaction parameters such as convenience, security, and trust in banks. In comparison, the Ukrainian context presented in this study emphasises institutional efficiency, in particular, how digital tools such as mobile banking and online lending expand access to finance.

N.P. Thi Hang (2024) addressed the specifics of digital inclusion in rural Vietnam, where the main barriers were a lack of digital education, weak infrastructure, and low levels of trust in

electronic services. The study argued that financial inclusion is correlated with the level of social support and digital adaptation. At the same time, L. Wewege *et al.* (2020) examined global challenges and trends in digital transformation, including the emergence of neobanks, the spread of blockchain, and the development of the FinTech ecosystem. These technologies are presented as drivers of change around the world. In this study, they are not just listed but analysed in the context of their implementation in the Ukrainian market, addressing the specifics of regulation and digital identification.

Digital banking services have become fundamental for transforming financial services for small businesses in Ukraine. Their widespread adoption reduced transaction costs, facilitated access to finance and optimised financial reporting. Incorporating regional differences, there is a steady upward trend in the level of trust in digital banking, which indicates its sustainability as a mechanism for ensuring the financial stability of businesses in times of economic turbulence.

Prospects for improving financial infrastructure for SMEs in the context of digital transformation

With the deepening digitalisation of the financial sector and the intensification of the FinTech environment, the issue of identifying barriers that prevent small and medium-sized enterprises from accessing digital banking products is becoming particularly relevant. Despite the overall growth in the penetration of online banking in the business environment, there are several systemic obstacles that limit the effective use of relevant tools, requiring an in-depth analysis of their nature and impact on the financial inclusion of businesses. The first group consists of technological barriers caused by both the insufficient level of digital infrastructure and the limited digital competence of business representatives. In rural and peripheral areas, unstable access to broadband Internet is often reported, which complicates the use of mobile banking applications and other digital platforms. In addition, some entrepreneurs have limited knowledge of how digital banking services work, which prevents them from making full use of such tools in their business activities (Nwoke, 2024).

The next group is financial barriers, which include limited access to lending through digital channels for entrepreneurs due to strict scoring criteria, lack of credit history or required documentation. Automated decision-making systems used by banks often do not address the specifics of micro and small businesses operating in the shadow or semi-formal economy. This reduces the probability of receiving financial support even if a stable but informal income is present. Regulatory barriers include fragmentation and insufficient adaptation of the legal and regulatory framework to digital financial transactions. Cybersecurity, personal data protection, the legal validity of electronic contracts, and electronic identification still need to be finalised. In addition, the complexity of integrating digital financial services with tax and accounting for small businesses creates additional difficulties in their full implementation (Soremekun *et al.*, 2024). Behavioural barriers, including entrepreneurs' distrust of digital channels due to fraud risks, insufficient transparency of financial decision-making mechanisms in mobile applications, and general psychological unpreparedness to switch to a digital financial management model, should be highlighted separately. The lack of consulting and information support from banking institutions exacerbates these barriers, limiting the level of adoption of digital products among the target audience. Thus, to ensure the full integration of small businesses into the digital financial environment, a set of measures is needed, including the development of technical infrastructure, improving financial literacy, adapting the regulatory framework, and increasing the transparency of financial services. Overcoming these obstacles will help strengthen financial inclusion, build institutional trust in digital tools, and boost entrepreneurial activity (Diener & Špaček, 2021).

In the context of the digital transformation of Ukraine's financial sector in the 21st century, the role of non-bank financial institutions is growing as core participants in the formation of an innovative digital financial ecosystem. Their activities not only complement the functions of traditional banks but also create the preconditions

for the accelerated development of financial services focused on the needs of small businesses, people with limited access to bank financing, and innovative market segments. Non-banking entities include financial companies, insurance, factoring, leasing companies, payment institutions and postal operators, as well as the latest FinTech platforms that provide a wide range of digital services. Such platforms include Stripe (Stripe, n.d.), a leading global online payment processing service that provides a wide range of API solutions for e-commerce integration, payment automation, subscription management and fraud protection. Stripe supports a variety of payment methods, including credit cards, digital wallets, and local payment systems, making it a versatile tool for businesses of all sizes. Payoneer (Payoneer, n.d.) is an international payment platform specialising in global B2B transfers and multi-currency payments, providing fast and secure money transfers between businesses and freelancers around the world. Payoneer also offers services for opening local bank accounts in different countries, which simplifies international transactions and avoids high foreign exchange fees. Using artificial intelligence, cloud technologies, automated application programming interfaces and blockchain technology, these platforms increase transparency, speed of service, reduce costs and expand access to digital financial services for small and medium-sized businesses. One of the key areas for non-banks to participate is to expand the range of financial services. In contrast to banks, which operate in a highly regulated legal environment, non-banks have more flexibility in developing new products and services (Ovsiienko, 2021). Summing up the identified barriers to the digitalisation of financial services for small businesses, including low digital literacy of entrepreneurs, limited access to the Internet in the regions, difficulty in using financial applications, lack of integration with accounting systems, and limited government support, it is possible to identify key areas that can significantly improve the efficiency of the use of digital services by small businesses. Table 2 summarises these areas according to the problems identified.

Table 2. Ways to improve the efficiency of digital services for small businesses

Areas for improvement	Expected results	Implementation subjects
Digital financial literacy	Raising entrepreneurs' awareness of digital tools and cybersecurity	Government, banks, business associations
Integration of digital services with accounting systems	Automation of financial accounting, reduction of errors	CRM/Enterprise Resource Planning (ERP) developers, banks
Simplifying access to online lending	Expanding lending through digital risk assessment	Banks, financial companies, NBU
Development of mobile applications for business	Increasing mobility and speed of interaction with the bank	Banks, FinTech companies
State support for SME digital transformation	Reduction of barriers to digitalisation	Ministry of Economy, Diia.Business, local authorities

Source: compiled by the authors based on O. Ovsiienko (2021)

Table 2 illustrates a multi-pronged approach to improving the use of digital services by small businesses in Ukraine, covering both technical and organisational aspects. On the one hand, special attention should be paid to improving the digital financial literacy of entrepreneurs, which is critical to reducing the risks of misuse of tools and increasing trust in online banking. On the other hand, the integration of banking products with CRM and ERP systems helps automate accounting processes, which in turn reduces business operating costs. In addition, the development of digital lending channels using big data analytics improves the accuracy of assessment of the creditworthiness of small businesses, which expands access to finance for entrepreneurs who do not have sufficient collateral or credit history. The "Affordable Loans 5-7-9%" programme, which covers about 40% of the hryvnia corporate loan portfolio and almost 50% of new loans disbursed, actively uses digital tools to simplify lending procedures. This provides SMEs with low-interest loans with fewer bureaucratic hurdles (Landa *et al.*, 2024). Equally

substantial is the increase in mobility through the development of specialised business applications that can be used by entrepreneurs to manage their finances quickly, regardless of their location. The importance of government support for SME digitalisation should also be highlighted, through programmes to compensate for the cost of implementing digital solutions, tax incentives, or soft loans. In August 2024, the Government of Ukraine approved the Strategy for the Recovery, Sustainable Development and Digital Transformation of SMEs until 2027 (Order of the Cabinet of Ministers of Ukraine No. 821-p, 2024), which provides for a set of measures to support SMEs, including digital transformation. It includes programmes to compensate for the cost of implementing digital solutions, tax incentives and soft loans for SMEs. The strategy aims to create favourable conditions for business development, including access to capital, deregulation and innovative development. At the same time, ensuring a high level of cybersecurity is a basic condition for the development of any digital financial services, as the growth of digital activity is accompanied by an increase in cyber threats.

The present study and K.M. Kumar *et al.* (2024) concurred in their conclusions on the role of digital financial instruments for SME development. K.M. Kumar *et al.* emphasised the need for government intervention and institutional adaptation to improve SMEs' access to digital financial services, particularly in a weak financial ecosystem. In contrast, this study focused on practical perspectives of improving financial infrastructure through the introduction of technological solutions, development of electronic identification and interoperable platforms. Both approaches emphasised the importance of digital transformation but differed in scope: K.M. Kumar *et al.* addressed the macro level, while this study focuses on the level of applied changes for SMEs. In the study by H. Harris & K. Sahija (2025), the authors analysed how digital transformation is changing the structure of banking services, focusing on consumer behaviour, the level of trust in digital channels, and the need for personalisation of financial services. The study emphasised the importance of strengthening cybersecurity, developing digital literacy, and adapting banking models to the needs of new generations of users. In turn, this study focused on the prospects for improving the financial infrastructure for small and medium-sized businesses in Ukraine in the context of digital transformation. In contrast, the study by V. Agarwal *et al.* (2024) focused on changing strategies for banks' interaction with customers in the context of digitalisation. Based on a survey of 600 customers, the authors found a positive impact of digital channels on customer acquisition, satisfaction, and loyalty, as well as challenges of personalisation and trust. Both studies recognised the importance of digital technologies for the transformation of the banking sector but differed in focus: the current study focused on financial inclusion for businesses, while Study V. Agarwal *et al.* focused on the behavioural aspects of customers. The study by O. Pyrog & A. Poritska (2020) noted that digital technologies contribute to the development of flexible business models and the improvement of financial infrastructure in Ukraine, which is central for the evolution of digital banking services and support for entrepreneurship.

In the context of the digitalisation of the financial sector, the issue of overcoming barriers to small businesses' access to digital banking services has become particularly relevant. The study demonstrated that despite the overall growth of digital services, technological, financial, regulatory, and behavioural barriers significantly limited their effective use. A comprehensive approach is needed to ensure that SMEs are fully integrated into the digital environment, including infrastructure development, financial literacy, easier access to credit, and government support. Overcoming these challenges will help increase financial inclusion, build trust in digital services, and boost entrepreneurial activity.

CONCLUSIONS

The survey results confirmed that digital banking services have become a key factor in transforming the financial environment of small and medium-sized businesses in Ukraine. In 2024, the share of non-cash transactions reached 94.6% by number and 51% by value, indicating the deep integration of digital tools into the financial behaviour of entrepreneurs. In

particular, 73.4% of transactions were payments in the retail network, and 31.1% were card-to-card transfers. At the same time, the number of successful identifications in the NBU's BankID system increased from 42.9 million in 2023 to 87.7 million in 2024, an increase of 104%. Of these, more than 81 million were for public services, including the Diia portal, and more than 5.1 million were for financial institutions, which indicates the active use of digital identification for commercial purposes. The role of mobile applications in the banking sector has been growing rapidly. In particular, the Monobank and Privat24 apps exceeded 10 million downloads each in 2024. The share of digital banking users among cardholders reached 94%, and 75% used mobile apps. About 51% of Ukrainians were ready to completely abandon physical visits to branches. This trend was also evident in the dynamics of service: in 2023, 79.5% of individuals conducted transactions remotely, which is almost twice as much as in 2019.

In 2024, Ukrainian entrepreneurs received 16,656 loans worth 62.2 billion UAH under the 5-7-9% programme, and over 329 billion UAH in total since its launch. More than 50% of these loans were provided online, through Privatbank, Monobank and FUIB. FUIB's average online loan for individual entrepreneurs reached 1.2 billion UAH in total, Monobank's loan amount was up to 0.5 million UAH per borrower, and PrivatBank provided loans of up to 1.6 million UAH. Thus, the digitalisation of banking services has significantly improved the speed, accessibility, and quality of financial services for small businesses. At the same time, several barriers need to be removed for full integration: technological, regulatory, financial, and behavioural. Ensuring a coherent digital financial infrastructure and strengthening government support will help deepen financial inclusion, increase SME performance, and create a sustainable business environment. The study was limited to analysing digital banking services only in the context of SMEs' access to finance, without the behavioural aspects of digital services consumption by end users. Further research should focus on assessing the impact of digital financial instruments on the financial sustainability of SMEs in a regional context and studying the effectiveness of government digital initiatives in supporting entrepreneurship.

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Вікторія Костюк
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0001-7671-3603
Олексій Муравський
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-7117-7335
Лідія Аврамчук
Кандидат педагогічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-7496-0392
Віталій Луценко
Аспірант
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0009-0009-6177-1806
Геннадій Чобану
Доктор економічних наук, старший науковий співробітник
Національний науково-дослідний інститут праці та соціального захисту
010643, вул. Поверней, 6-8, м. Бухарест, Румунія
Бухарестський університет Artifex
060754, вул. Економіу Чезареску, 47, м. Бухарест, Румунія
https://orcid.org/0000-0002-2361-9717

Еволюція цифрових банківських послуг в Україні: вплив на розвиток підприємництва та фінансову інфраструктуру

Анотація. Актуальність даного дослідження зумовлена стрімкою цифровізацією фінансового сектору України та необхідністю забезпечення малого та середнього бізнесу ефективними інструментами доступу до фінансування в умовах економічної трансформації. Метою даного дослідження було оцінити вплив цифрових банківських сервісів на доступ малого та середнього бізнесу до фінансування в Україні. Для цього було проведено комплексний аналіз нормативно-правової бази, статистичних даних щодо частки безготівкових операцій, активності фінансово-технологічних компаній і тенденцій

цифровізації у банківському секторі. Аналіз статистичних даних за 2023-2024 роки показав, що частка безготівкових операцій із платіжними картками сягнула 94,6 % за кількістю, а загальна кількість таких операцій становила 8,65 млрд у 2024 році. Кількість ідентифікацій через систему BankID Національного Банку України зросла більш ніж удвічі – з 42,9 млн у 2023 році до 87,7 млн у 2024 році. Мобільні додатки найбільших банків, зокрема Monobank та Приват24, у 2024 році були завантажені понад 10 млн разів кожен. За програмою «Доступні кредити 5-7-9 %» у 2024 році підприємці отримали понад 16 тисяч кредитів на суму понад 62 млрд грн. У 2025 році рівень цифровізації банківських послуг для бізнесу у регіонах України перевищував 80 %. Ці результати свідчать про глибоку інтеграцію цифрових банківських сервісів у фінансову діяльність малого і середнього бізнесу, значне розширення доступу до фінансових ресурсів та суттєве підвищення фінансової інклюзії. Практичне значення дослідження полягає у створенні основ для покращення цифрової фінансової інфраструктури, що сприятиме подальшому розвитку та підвищенню доступності фінансування малого та середнього бізнесу в Україні

Ключові слова: діджитал-банкінг; фінансові технології; цифрова трансформація; онлайн-банкінг; мобільний банкінг; блокчейн

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Yuliia Pereguda*
Doctor of Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
Interregional Academy of Personnel Management
03039, 2 Frometivska Str., Kyiv, Ukraine
https://orcid.org/0000-0002-1434-2509

Transformation of Ukrainian agricultural business in the context of transition to a circular green development model

Abstract. Finding ways to develop Ukrainian agribusiness in the context of the transition of economic systems at different levels to a circular green development model is a pressing and critical task to improve national and food security, as well as to ensure sustainable growth of the national economy. The study aimed to formulate directions for accelerating the transition of Ukrainian agricultural enterprises to a circular green business model by identifying trends and problems in the development of the country's agro-industrial complex, defining the specifics of Ukraine's transition to a circular green model, and identifying the advantages and challenges that accompany the process of transitioning agribusiness to a circular green development model. The study was based on the integrated use of such methods as: literary analysis; data collection and analysis (desk research); bibliographic method; comparative evaluation; economic analysis; Ishikawa diagram; systematisation, grouping and logical generalisation. The study highlighted the need for agricultural enterprises to adopt a circular green development model as part of the transition to post-industrial business principles. The economic analysis identified trends and problems in the development of Ukraine's agro-industrial complex, as well as the challenges that accompany the country in its transition to a circular green development model. The study identified the positive aspects of the transition of Ukrainian agricultural enterprises to a circular green development model. Separately, using the Ishikawa Diagram, the cause-and-effect relationships of the problems of transition to a circular green model of agribusiness development in Ukraine were identified, where six groups of problems were identified (institutions, society, markets, technology, personnel, and finance). Ways of reforming the agricultural business of Ukraine within the framework of ensuring the transition to a circular green model of development were proposed. The results obtained in the course of the study are of high practical

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*Corresponding author

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importance for Ukrainian agricultural producers, as they accelerate the transition to a circular green development model and increase competitiveness and resilience to economic challenges

Keywords: ecology; economy; competitiveness; post-industrial transition; resources; reforms

INTRODUCTION

The transformation of economic systems at various levels (global, international, national, sectoral, regional, groups of enterprises, individual enterprises, individual households) in the context of the transition to a post-industrial model of development puts forward new requirements for doing business and for business units to find their directions of strategic development. The most popular models of strategic development for business units in the post-industrial transition are the "green" development model and the "circular" development model. The most popular models of "green" and "circular" development are for business units belonging to sectors that have a critical negative impact on the environment, both in individual countries and in the world, which includes the agricultural sector.

Foreign and Ukrainian scholars have paid considerable attention to the transition of agricultural business to a "green" or "circular" model of development. In their research, American scientists M. Khanna *et al.* (2024) addressed the issue of introducing and developing a circular bioeconomy in the food and agricultural sectors of the economic systems of states. The researchers tried to combine two modern models of business development (circular and bioeconomy) into a comprehensive one (circular bioeconomy), as well as present five critical ways to achieve a circular bioeconomy within a market economy. The approach of Indonesian scientists S.P. Mulya *et al.* (2024), who studied the peculiarities of implementing the circular economy in agriculture, considering the regional peculiarities of agribusiness development. The researchers identified twelve features that affect the implementation of the circular economy in agribusiness in different regions of the world, namely: raw materials, circularity, waste, processes, inputs, sector/subsector, dimensions, type of object, regional aspects, procedures, purpose, and policies/systems.

J.F. Velasco-Muñoz *et al.* (2021) studied the problems of implementing the circular economy in agriculture and agricultural business and drew attention to the fact that the theoretical basis of the circular economy is not fully adapted to the practical challenges posed by agricultural business. The researchers analysed the principles and strategies of the circular economy that can be used by business units in the agricultural sector. Scientists from China and Bangladesh, Z. Chen *et al.* (2022) studied the peculiarities of green agriculture development in China, focusing on the study of the geographical structure of green agribusiness in the country, highlighting the specifics for individual regions of China. Identification of the causes of imbalance in the development of green agribusiness in different regions of China was emphasised.

N.V. Fedorchuk (2021) analysed the implementation of the EU's European Green Deal programme in Ukraine (European Commission, n.d.) with an emphasis on Ukrainian agribusiness. Based on the study of the practice of implementing the programme for agribusiness in the European Union, the author makes recommendations for Ukrainian agricultural producers and describes the risks and challenges that the implementation of the programme for Ukrainian agriculture poses. A.I. Shvets (2022) revealed the benefits of the circular economy for Ukraine and possible priority areas of circular economy development for the country. The impact of the EU's European Green Deal programme on Ukraine (European Commission, n.d.) and the study of how the Ukrainian economy can integrate into European initiatives for the development of the circular economy were emphasised.

Ukrainian scientists V. Shebanin *et al.* (2024) analysed the peculiarities of implementing the circular economy in the agricultural sector of Ukraine, considering the peculiarities of its development, which were formed, including under the influence of Russian military aggression. The study noted the problems of intensifying the implementation of circular economy principles in the agricultural business of Ukraine. O.S. Pavlenko (2023), based on an

assessment of the current state and prospects for the introduction of the "green economy" model in agribusiness in the world, as well as a study of the Concept of "Greening the Economy with Agriculture GEA", proposes the main directions for the development of Ukrainian agribusiness within the framework of the introduction of the "green economy" model.

Given the importance of the agricultural sector for Ukraine's economy and the impact of agricultural business on the national business environment, as well as the limited research on the transition of agricultural enterprises to the circular green model (CGM), there is a need to find ways to accelerate the transition of Ukrainian agricultural enterprises to the circular green model, which will combine the components of both circular and green models of business unit development. The aforementioned defined the study aim to determine ways to reform the agricultural business of Ukraine within the framework of ensuring the transition to a circular green model of development.

MATERIALS AND METHODS

The following methods were used to conduct the study: literature analysis; data collection and analysis (desk research); bibliographic method; comparative assessment; economic analysis; Ishikawa diagram; systematisation, grouping and logical generalisation. The research period is from 2010 to 2024. The method of literature analysis identified the issues of scientific research on the "green" and "circular" economy in general and in the field of agricultural business in particular. The literature analysis identified the approaches of scientists to determine the benefits of using the green and circular economy in the agro-industrial complex, as well as the problems of using the green and circular economy in agribusiness. The data obtained in the course of the literature analysis became the basis for the development of the author's approach to the formation of advantages and problems of the transition of Ukrainian agribusiness to a circular green model of development. The literature analysis was based on the works of M. Khanna *et al.* (2024), J.F. Velasco-Muñoz *et al.* (2021), V. Shebanin *et al.* (2024) and other scholars.

The desk research method involved the use of data from the State Statistics Service of Ukraine for 2010-2024 on: GDP, the volume of the agro-industrial complex of Ukraine (State Statistics of Ukraine, 2025a); the volume of national exports, exports of products of the country's agro-industrial complex, the foreign trade balance and the foreign trade balance for agricultural products of Ukraine (State Statistics of Ukraine, 2025b). The desk-based method of the study also involved the use of data on the Global Green Economy Index (GGEI) by country (Cape Verde, Tanzania, Niger, the United States, Mexico, Trinidad and Tobago, Japan, China, Israel, India, Uzbekistan, New Zealand, Australia, Denmark, Sweden, Germany, France, Italy, Ukraine, Iceland, Malta) for the period from 2005 to 2023 (The Green Growth Index, n.d.b). The data for the study were taken from the year of the first GGEI calculation (2005) to the last year when data were available (2023). The data obtained during the desk study were used to analyse the impact of the agro-industrial complex on the development of the Ukrainian economic system to determine the level of transition of the Ukrainian economic system to a circular green development model.

The method of comparative assessment compared the models of strategic development of business units within the post-industrial transition (circular, green, socially oriented, social, digital, innovative, classical), which further substantiated the recommendations on the need for agribusiness to switch to a circular green development model. The method of economic analysis was used to identify patterns and trends in the development of the agro-industrial complex of Ukraine, including exports and the foreign trade balance. It determined the dynamics of development of the agro-industrial complex of Ukraine in 2010-2024. The following key indicators were used for the analysis: Country's GDP; Country's agro-industrial complex; Share of agro-industrial complex in GDP; National exports; Exports of agro-industrial complex products; Share of agro-industrial complex products exports in Ukraine's national exports; Foreign trade balance of Ukraine; Foreign trade balance for agro-industrial complex products of Ukraine (State Statistics of Ukraine, 2025a; State Statistics of Ukraine, 2025b).

The use of the Ishikawa Diagram (Ishikawa, 1968) presented the cause-and-effect relationships of the issues of transition to a circular

green model of agribusiness development in Ukraine by the groups of key problems identified (institutions, society, markets, technologies, personnel, finance). The methods of systematisation, grouping and logical generalisation were used in the study to systematise information, formulate conclusions and scientific proposals of the article.

The study was conducted using the following legal and regulatory documents: Resolution of the Cabinet of Ministers of Ukraine No. 932-p (2016), Resolution of the Cabinet of Ministers of Ukraine No. 820-p (2017), Ministry of Environmental Protection and Natural Resources of Ukraine (2018), Resolution of the Cabinet of Ministers of Ukraine No. 117-p (2019), Law of Ukraine No. 2697-VIII (2019), Law of Ukraine No. 2320-IX (2023).

RESULTS AND DISCUSSION

The transformation processes occurring at different levels of economic systems (global, international, national, sectoral, regional, groups of enterprises, individual enterprises, individual households) and caused by the accelerated transition to a post-industrial model of economic development require businesses to respond adequately and choose effective directions of strategic development (Gibson, 1993). It is necessary to determine the right model for strategic development within the framework of post-industrial transition, since the chosen model of strategic development determines the competitiveness of the enterprise and its products (works, services) in sales markets, including external ones, the efficiency of resource use, as well as the level of loyalty to the business unit on the part of its counterparties, including consumers of products (works, services) and personnel. There are several main models of strategic development that can be chosen by business units in the post-industrial transition, each of which has unique characteristics (Table 1).

Table 1. Comparative assessment of models of strategic development of business units in the framework of post-industrial transition

Evaluation feature	Models of strategic development of business units in the post-industrial transition						
	Circular	Green	Socially oriented	Social	Digital	Innovative	Classic
Key objective	Customer satisfaction through the introduction of circularity in production	Customer satisfaction based on zero (positive) environmental impact	Customer satisfaction through increased social support for employees and society	Social support for employees and social responsibility	Customer satisfaction through the digitalisation of business processes	Customer satisfaction through the implementation of innovative solutions in business processes	Customer satisfaction through the most efficient use of resources
Key performance indicators	Profit and reduced use of new resources	Profit and ecosystem restoration and development	Profit and social protection of staff and society	Social protection of staff, specific social groups and society as a whole	Profit and digital efficiency	Profit and innovation efficiency	Profit
Key element of business processes	Circularity	Eco-friendliness	Social support	Social protection	Digitalisation	Innovation	Access to resources
Relationship with counterparties	Co-operation	Co-operation	Social support	Social protection	Co-operation	Co-operation	Exploitation of the asymmetry of information
Relationship with competition	Competition and equal struggle	Competition and equal struggle	Competition and equal struggle	Co-operation	Competition and equal struggle	Competition, equal struggle and cooperation	Antagonistic struggle

Table 1, Continued

Evaluation feature	Models of strategic development of business units in the post-industrial transition						
	Circular	Green	Socially oriented	Social	Digital	Innovative	Classic
Attitude towards staff	Training and maximum involvement in business processes	Training and supporting green initiatives	Training and professional development	Inclusive professional development and social protection	Development of digital competences and digital replacement	Training and supporting innovative activity	Increase productivity, efficiency and effectiveness
Areas of implementation in business activities	All	All	All	Limited quantity	All	All	All

Source: compiled by the author based on research of V. Dutot & C. Van Horne (2015), U.A. Cullen (2021), O. Prokopenko *et al.* (2024)

The peculiarities of the models of strategic development of business units in the post-industrial transition require their combined use by businesses. On the other hand, limited resources inhibit the yse of any models in conjunction. It is necessary to set priorities, considering the specifics of production activities and the requirements of consumers, society and government institutions. Under these conditions, agribusinesses should implement a circular green model of strategic development. This is especially substantial for agribusinesses in countries where the agricultural sector is a key sector of the economy, including Ukraine.

Every year, the global agricultural business generates up to 1.6 billion tonnes of food waste and 3.3 billion tonnes of greenhouse gases and is the fifth largest polluter of the global ecosystem (Magnus, n.d.). On the other hand, to provide food for the growing world population by 2050, the agricultural sector needs to increase agricultural production by 70% (Aznar-Sánchez *et al* 2019). Ensuring production growth while reducing the burden on ecological systems in the agricultural sector is possible only through the transition to a circular green development model. Those countries that ensure a rapid transition to a circular green model of development of national agricultural producers will receive increased national and food security; new drivers for economic development; improved environmental situation; increased competitiveness of national agricultural products in global, international and national markets; increased prosperity of the population; and sustainable and innovative development of the economic system and society. This situation requires accelerating the transition to a circular green model of development of the agro-industrial complex, agricultural business and agricultural enterprises of Ukraine.

Agricultural business is one of the leading areas of business activity in Ukraine. The agricultural sector is the driver of the national economic system and accounts for a significant share of the national GDP (Table 2). For the analysis in Table 2, the following statistics were used: 2010 (the year of recovery of Ukraine's economy after the global crisis); 2014 (the year before the economic crisis in Ukraine); 2017 (the year of the peak of crisis manifestations in the Ukrainian economy); 2018 (the year of the beginning of the recovery of Ukraine's economy after the economic crisis); 2019 (the year of the pandemic); 2021 (the year of recovery from the pandemic crisis in Ukraine); 2022-2024 (the years of military development of the Ukrainian economy).

Table 2. Analysis of the dynamics of GDP and the agro-industrial complex (AIC), as well as the share of the AIC in Ukraine's GDP, 2010-2024

Metric	Years									2024 in %, before	
	2010	2014	2017	2018	2019	2021	2022	2023	2024	2010	2023
GDP, billion UAH	1,079.4	1,586.9	2,981.2	3,560.3	3,977.2	5,450.9	5,239.1	6,628.0	7,658.7	709.5	115.6

Table 2, Continued

Metric	Years									2024 in %, before	
	2010	2014	2017	2018	2019	2021	2022	2023	2024	2010	2023
AIC, billion UAH	80.4	161.2	303.4	361	356.6	593.4	449.2	500.5	544.6	677.4	108.8
Share of the agricultural sector in GDP, %	7.4	10.2	10.2	10.1	9.0	10.9	8.6	7.6	7.1	95.5	94.2

Source: calculated by the author based on the State Statistics of Ukraine (2025a)

According to the analysis in Table 2, it is possible to note that the agro-industrial complex (AIC) occupied a significant share in the Ukrainian economy during the study period, which ranged from 7.1% of the national GDP (2024) to 10.9% of the national GDP (2021). Table 2 also shows the significant impact of socio-political challenges on the Ukrainian agro-industrial complex. Thus, in 2019, at the beginning of the pandemic, in the context of 11.7% GDP growth, production in the national agro-industrial complex decreased by 1.2%, while Russian military aggression against Ukraine and logistical problems with the outbreak of war led to a significant drop in agricultural production (-24.3% in 2022 by 2021) and a slow recovery of the agro-industrial complex (-8.2% in 2024 by 2021) in the context of of a rapid recovery of the country's economic system (+40.5% in 2024 by 2021). According to Table 2, it is possible to conclude that until 2021, the agro-industrial complex was one of the drivers of the Ukrainian economy. Thus, while Ukraine's GDP grew by 405.0% between 2010 and 2021, the national agro-industrial complex grew by 638.1% over the same period. In 2022-2024, the situation in the agro-industrial complex deteriorated, requiring the search for new strategic solutions to accelerate the development of agribusiness in the country, where one of the key solutions could be the introduction of a circular green model of strategic development by Ukrainian agricultural enterprises.

During the study period, Ukraine's agricultural sector had a critical impact on national exports (Table 3). For the analysis presented in Table 3, statistical data for key periods of Ukraine's economic development was used: 2010 was marked by the recovery from the global crisis, 2014 was the pre-crisis stage in Ukraine, 2017 was characterised by the deepest crisis manifestations, 2018 marked the beginning of economic growth, 2019 was the year of the pandemic, 2021 was the year of recovery from the pandemic crisis, and 2022-2024 was the period of military restructuring of the Ukrainian economy.

Table 3. Analysis of the dynamics of national exports and exports of agricultural products, as well as the share of agricultural exports in Ukraine's total exports, 2010-2024

Metric	Years									2024 in %, before	
	2010	2014	2017	2018	2019	2021	2022	2023	2024	2010	2023
Export, million USD USA	51,430.5	53,901.7	43,264.7	47,335	50,054.6	68,072.3	44,135.6	36,182.9	41,733.1	81.1	115.3
Export AIC, million USD USA	9,936	16,668.9	17,756.9	18,611.8	22,144.1	27,708.9	23,390	22,000.7	24,683.2	248.4	112.2
Share of AIC in total exports, %	19.3	30.9	41.0	39.3	44.2	40.7	53.0	60.8	59.1	306.1	97.3

Source: calculated by the author based on the State Statistics of Ukraine (2025b)

According to Table 3, the share of exports of agricultural products grew during the study period and reached 60.8% of total national exports in 2023. At the same time, crisis manifestations in the national economy (the crisis of 2014-2017, the pandemic of 2019-2020, and Russian military aggression against Ukraine since 2022) led to an increase in the share of agricultural exports in national exports. At the same time, the decreasing impact of the crisis on the national economic system led to a decline in the share of agricultural exports in national exports (2018, 2021, 2024). Based on the analysis in Table 3, it is possible to conclude that the devaluation and inflationary processes occurring in the country as part of the economic crisis have a positive impact on the export of agricultural products. On the other hand, there is a significant potential for increasing exports of agricultural products by using new models of agribusiness development in the country, one of which could be a circular green model of strategic development. The foreign trade balance of agricultural products had a positive impact on the foreign trade balance of Ukraine during the study period (Table 4). To analyse Table 4, statistical data for key years was used: 2010 – recovery after the global crisis, 2014 – pre-crisis period in Ukraine, 2017 – peak of the economic crisis, 2018 – start of the economic recovery in Ukraine, 2019 – start of the pandemic, 2021 – recovery from the pandemic crisis in Ukraine, 2022-2024 – period of military transformation of the Ukrainian economy.

Table 4. Analysis of the dynamics of the foreign trade balance and the foreign trade balance by agricultural products of Ukraine, 2010-2024

Metric	Years									2024 in %, before	
	2010	2014	2017	2018	2019	2021	2022	2023	2024	2010	2023
Foreign trade balance, USD million USA	-9,309.5	-527.0	-6,342.5	-9,852.6	-10,745.5	-4,770.8	-11,160.2	-27,384.1	-29,018.1	311.7	106.0
Foreign trade balance of the AIC, million USD USA	4,174.1	10,609.7	13,455.7	13,556.3	16,408.1	19,962.0	17,348.8	15,046.5	17,043.1	408.3	113.3

Source: calculated by the author based on the State Statistics of Ukraine (2025b)

An analysis of Table 4 shows that, in the context of Ukraine's negative foreign trade balance in the years selected for the study, the foreign trade balance in agricultural products was positive in all the years selected for the study. The data in Table 4 indicate an increase in the foreign trade balance for agricultural products in the period from 2010 to 2021, and problems in 2022-2024 caused by economic problems due to Russian military aggression against Ukraine and logistical problems. Given the above, it is possible to conclude that the agricultural sector can have a decisive impact on reducing and eliminating Ukraine's negative foreign trade balance. To do this, it is necessary to search for and implement new models of agribusiness development in the country, one of which could be a circular green model of strategic development.

In the future, it is appropriate to assess the level of transition of Ukraine's economic system to a circular green model of development using the Global Green Economy Index (GGEI). The GGEI covers 160 countries and is calculated based on 18 indicators, measuring both the country's progress on these indicators since 2005 and the distance of each indicator from the Sustainable Development Goals (SDGs), the Paris Climate Agreement and the Aichi Biodiversity Targets (The Dual Citizen, 2025). The Global

Green Economy Index scores range from 1 to 100: 1-20 – very low transition; 20-40 – low transition; 40-60 – moderate transition; 60-80 – high transition; 80-100 – very high transition. The highest score of 100 indicates that the country has achieved its sustainable development goals (The Global Green Growth Institute, 2025).

For the assessment, data for the year when the GGEI was first calculated (2005) and the most up-to-date data available (2023) were selected. At the same time, the Global Green Economy Index of Ukraine in the years of the study with the countries by region of the world that have the highest (leaders) and lowest (outsiders) values of the index, as well as economically developed and developing countries that have the greatest influence on the global economic system, were compared (Table 5).

Table 5. Assessment of the global, international and national economic systems for the transition to a circular green development model in 2005-2023

Region/country	Year and place of the country in the region		Abs. deviation
	2005	2023	
Africa			
Cape Verde	58.20 (1)	47.18 (5)	-11.02
Tanzania	37.63 (9)	55.56 (1)	17.93
Niger	20.69 (24)	24.49 (24)	3.80
The highest GGGI value in Africa	58.20	55.56	-2.64
The lowest GGGI value in Africa	20.69	24.49	3.80
USA			
USA	58.60 (1)	60.31 (2)	1.71
Mexico	58.41 (2)	61.64 (1)	3.23
Trinidad and Tobago	29.56 (20)	30.29 (20)	0.73
Maximum GGGI value in America	58.60	61.64	3.04
Minimum GGGI value in America	29.56	30.29	0.73
Asia			
Japan	66.00 (1)	61.83 (1)	-4.17
China	52.07 (6)	58.33 (3)	6.26
Israel	52.11 (5)	49.24 (10)	-2.87
India	40.88 (14)	43.54 (14)	2.66
Uzbekistan	19.87 (33)	25.83 (33)	5.96
Maximum GGGI value in Asia	66.00	61.83	-4.17
Minimum GGGI value in Asia	19.87	25.83	5.96
Oceania			
New Zealand	58.08 (1)	56.33 (1)	-1.75
Australia	50.12 (2)	53.67 (2)	3.55
Maximum GGGI value in Oceania	58.08	56.33	-1.75
Minimum GGGI value in Oceania	50.12	53.67	3.55
Europe			
Denmark	74.64 (1)	76.77 (2)	2.13
Sweden	73.17 (2)	78.72 (1)	5.55
Germany	68.08 (7)	75.83 (4)	7.75
France	65.10 (12)	68.85 (17)	3.75
Italy	66.28 (9)	68.06 (19)	1.78
Ukraine	50.87 (30)	51.31 (33)	0.44
Iceland	27.60 (38)	52.23 (31)	24.63
Malta	38.06 (36)	31.76 (38)	-6.3

Table 5, Continued

Region/country	Year and place of the country in the region		Abs. deviation
	2005	2023	
Europe			
Maximum GGGI value in Europe	74.64	78.72	4.08
Minimum GGGI value in Europe	27.60	31.76	4.16
Maximum global GGGI value	74.64	78.72	4.08
Minimum global GGGI value	19.87	24.49	4.62

Note: the country's position in the region according to GGGI is indicated in brackets
Source: calculated by the author based on The Green Growth Index (n.d.a), The Green Growth Index (n.d.b)

Ukraine has demonstrated a moderate level of transition to a circular green development model throughout the study period (Table 5). At the same time, over the period from 2005 to 2023, there was a positive trend in the Global Green Economy Index for the country (+0.44). However, negative aspects of Ukraine's transition to a circular green development model are clearly visible, namely in terms of transition, Ukraine was among the outsiders in Europe (in 2005, 30th place out of 38 countries, in 2023, 33rd place out of 38 countries), which carries significant risks and a decrease in the competitiveness of the national economic system and its components, especially in the markets of the European Union; during the study period, Ukraine lost places according to the GGEI among European countries (-3 places), which indicates that the country is lagging behind in the introduction and implementation of measures to ensure the transition to a circular green development model; the growth rate of the Global Green Economy Index for Ukraine in On the other hand, the value of the Global Green Economy Index for Ukraine leaves an adequate basis for increasing the country's transition to a circular green development model, where agricultural enterprises can become drivers of such a transition. Ukraine has already formed a legislative and regulatory framework for the transition of the national economic system and the agricultural sector to a circular green development model. The following legislative and regulatory documents can be identified: Resolution of the Cabinet of Ministers of Ukraine No. 932-p (2016), Resolution of the Cabinet of Ministers of Ukraine No. 820-p (2017), Ministry of Environmental Protection and Natural Resources of Ukraine (2018), Resolution of the Cabinet of Ministers of Ukraine No. 117-p (2019), Law of Ukraine No. 2697-VIII (2019), Law of Ukraine No. 2320-IX (2023).

As part of the transition to a circular green model of development, Ukrainian agribusiness should address the benefits and challenges of the transition to the CSM. Scientific studies conducted by scientists have separately identified the benefits of either a green or a circular development model for Ukrainian agribusiness, which carries limitations. O. Kovalova (2025) highlighted the advantages of the Smart economy, which includes the green economy. The benefits include human capital development, increased labour mobility, and improved quality and inclusiveness of education. I. Samoilyk & M. Vernygora (2023) addressed the following benefits of the circular economy for agribusiness in Ukraine: accelerating digitalisation; improving product quality and quality control over production; accelerating integration into international and global food systems; improving logistics. N. Usata (2023) highlighted the following benefits of the circular economy for the national agro-industrial complex: waste reduction; resource saving; increased innovation activity of enterprises; reuse of resources; synchronisation of supply and demand; stimulation of economic system growth. A. Shvets (2022) identified the following advantages of the circular development model: resource saving; resource reuse; development of innovative activities; improvement of the quality of meeting the needs of the population; and an increase in income of all economic actors. The transition to a circular green model of agribusiness development in Ukraine will have benefits for the national economy, agricultural producers, society, and households (Table 6).

Table 6. Benefits of transitioning Ukrainian agribusiness to a circular green development model

Subject	Advantages
The national economy	Acceleration of economic growth; increase in the competitiveness of the country's economy; increase in innovation; reduction of resource costs; improvement of resource efficiency; increase in exports; reduction of the negative foreign trade balance; increase in investment; and development of human capital.
Agricultural producers	New incentives for growth; increased competitiveness of agricultural products in national and foreign markets; increased investment attractiveness; increased innovation activity; improved quality of personnel; increased customer loyalty to the company and its products.
Society	Improvement of the environmental situation; reduction of the area of landfills; improvement of the quality of agricultural products; improvement of the quality of life; increase in the quality and inclusiveness of education; reduction of health problems among the population.
Households	Increased incomes; increased labour market supply; improved quality of agricultural products; increased educational opportunities.

Source: compiled by the author of the study

Identification of problems and barriers to the transition to a circular green model of agribusiness development in Ukraine is a key scientific, theoretical and practical aspect. Studies address the problems of transition to either a green or a circular model of development of agribusiness enterprises, which have limitations. O. Kovalova (2025) identified the disadvantages of the Smart economy, which includes the green economy. The disadvantages include resistance of the population (staff, employees); the presence of institutional traps; ineffective human capital management. N. Ilchenko & O. Marchenko (2024) identified four groups of problems of transition to a circular model of development: regulatory (institutional), market, technological, and cultural. I. Samoilyk & M. Vernygora (2023) addressed the following disadvantages of the transition of agribusiness to a circular model of development: disruption of supply chains; increased transaction costs, especially in the case of exports; and the need for a radical restructuring of operational processes. It is worth highlighting the key groups of problems of transition to the circular green model of agribusiness development in Ukraine, which can be presented in the form of the Ishikawa Diagram (Ishikawa, 1968) in Figure 1.

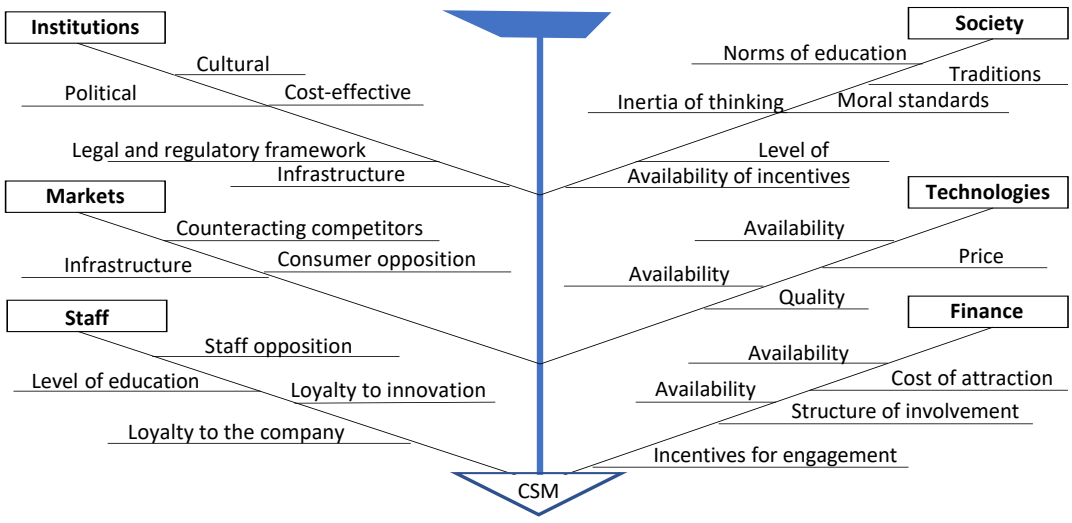

Figure 1. Ishikawa diagram of the cause-and-effect relationships of the problem of transition to a circular green model of agribusiness development in Ukraine

Source: compiled by the author of the study

According to the Ishikawa diagram (Fig. 1), it is possible to distinguish six groups of problems of transition to the circular green model of agribusiness development in Ukraine: the presence and development of cultural, political, economic, infrastructure institutions, as well as the legislative and regulatory framework; problems of society development (upbringing, traditions, morality, education, incentives, inertia of thinking); market development (competitors, consumers, infrastructure); availability, accessibility, price and quality of technologies; development and behaviour of personnel (education, resistance, loyalty to innovations and enterprises); availability, price of attracted Taking into account the study, it is appropriate to outline the ways of reforming the agrarian business of Ukraine in the framework of ensuring the transition to a circular green development model:

1. Transformation of corporate strategies of agricultural enterprises with a shift in their focus to greener production and sales, development of green technologies, introduction of circular business principles, and innovation.

2. Reformation of the system of staff training/retraining with a focus on developing inclusive professional competences, stimulating innovation, developing digital competences, and environmental literacy.

3. Development of digitalisation of production and management processes to reduce resource consumption, promote resource reuse, and reduce negative environmental impact.

4. Changes to production and operational activities with a focus on reducing the negative impact on the environment and increasing the circularity of production processes.

5. Transformation of management activities with a shift in focus to involve managers in the development, implementation and effective implementation of green and circular management solutions.

6. Changes in corporate culture to increase loyalty and support of green and circular management solutions by managers and employees.

7. Search and elimination of institutional traps in the production, economic and management activities of enterprises in the context of the development, implementation and effective implementation of "green" and "circular" management solutions.

8. Reformation of the system of relations with competitors and contractors, including state institutions, on the principles of ensuring equality of relations and fair competition in the context of developing, implementing and effectively implementing "green" and "circular" management solutions.

9. Increased influence on society and individual social groups to introduce green and circular principles into social and economic relations.

10. Development of markets to promote the introduction of green products and products based on circular technologies.

11. Active influence on external institutions, including the country's legislative and regulatory framework, to accelerate the transition to a circular green development model.

The results of the study demonstrate the need for comprehensive reform of Ukraine's agrarian business towards a circular green development model. Transformation of corporate strategies, implementation of environmental and digital solutions, updating of the personnel training system, changes in management approaches and corporate culture, as well as active influence on markets, society and the legislative environment are necessary for the transition of Ukrainian agribusiness to a circular green development model. Ensuring the rapid transition of Ukraine's agricultural business to a circular green development model will create long-term and sustainable benefits for Ukraine's economic system, agricultural producers, society and households.

When ensuring the transition of Ukrainian agribusiness to a circular green model of development, it is necessary to address the features of the CGM. U.A. Cullen (2021) addressed the transformation of institutions as the main feature of the transition to a circular economy, S.P. Mulya *et al.* (2024) identified twelve key features of the transition to a circular model of agribusiness development (raw materials, circularity, waste, processes, inputs, sector/subsector, dimensions, type of facility, regional aspects, procedures, purpose, and policies/systems), O. Prokopenko *et al.* (2024) shifted the focus to increasing profits as a key feature of the transition of enterprises to a green development model.

In the study, the features of the circular and green models of strategic development of business units in the post-industrial transition are detailed by key goal; key performance results; key elements of business processes; attitude to competitors, contractors and staff; areas of implementation in business activities. This approach is more detailed and structured.

At the same time, A.H. Samo *et al.* (2023) identified the following areas for the transition of agricultural producers to a green development model: development of formal institutions, state support, technology development (without specifying technologies), economic incentives, infrastructure development, personnel training, competitiveness, and innovation development (without specifying areas). Z. Xiang *et al.* (2024) emphasised green intellectual capital and innovations in the field of sustainable business models as key components of the transition of business entities to a green development model. The proposals offered in the study are broader and more adapted to Ukrainian agricultural producers, although they are partially similar to those of A.H. Samo *et al.* (2023) in terms of training and technology development (with an emphasis on digital technologies), as well as to the proposal of Z. Xiang *et al.* (2024) in intellectual capital development and innovation.

The transition to a circular green model of development has its advantages and disadvantages. O. Kovalova (2025) identified four basic advantages (human capital development, increased labour mobility, improved quality and inclusiveness of education) and four basic disadvantages (resistance of the population (staff, employees), institutional traps, ineffective human capital management) of the transition to a green development model. I. Samoilyk & M. Vernygora (2023) analysed four key advantages (digitalisation, quality, integration and improved logistics) and three key disadvantages (supply chains, transaction costs and change in operational processes) of the transition to a circular model of development. A. Shvets (2022) highlighted the following advantages of the circular development model: optimisation of resource use (savings, reuse), innovation, meeting the needs of the population, and income. Instead, N. Ilchenko & O. Marchenko (2024) addressed the following problems of transition to a circular model of development: transformation of institutions, development of markets, development and use of technologies, and adaptation of cultural development to a new model of economic relations. The study divides the benefits of the transition to a circular green development model into four groups (for Ukraine's economic system, agricultural producers, society, and households) and presents them in a broader way than in the works of other scholars. The disadvantages of the transition to the CGM are presented in the form of an Ishikawa diagram and divided into six groups, which disclosed them more widely than in the works of Ukrainian and foreign scientists.

It is possible to conclude that there are significant opportunities for the development of the agro-industrial complex and agricultural enterprises of Ukraine within the framework of the transition to the CGM. The transition to the circular green model of development will improve the completeness of Ukrainian agribusiness in foreign and domestic markets and will provide a new impetus for the development of both individual enterprises and the agricultural sector and the national economy.

CONCLUSIONS

The study proved the need to accelerate the transition of Ukrainian agribusiness to a circular green model of development. Based on a comparative assessment of the models of strategic development of business units within the post-industrial transition (circular, green, socially oriented, social, digital, innovative, classical), as well as statistics on the environmental impact of the agro-industrial complex (annually the global agricultural business generates up to 1.6 billion tonnes of food waste and 5 billion tonnes of greenhouse gases. Tonnes of food waste and 3.3 billion tonnes of greenhouse gases, making it the fifth largest pollutant for the global ecosystem. It was determined that the circular green development model is optimal for agricultural enterprises, especially in countries that have a developed agricultural sector of the national economy, which includes Ukraine.

An analysis of the development of Ukraine's economy and agriculture in 2010-2024 has highlighted the key importance of agriculture

and agribusiness for the country's economic system (more than 7% of GDP was accounted for by agriculture during the study period), as well as the problems and constraints that hinder the development of agricultural enterprises. The study proved that the Russian military aggression has significantly slowed down the development of agribusiness in the country, the agro-industrial complex grew by 108.8% in 2024 compared to 2023 against 115.6% growth of the national economy, and agribusinesses should seek new ways to develop, where the transition to a circular green model of development should be a key one.

The study of the level of transition of Ukrainian economic system to a circular green development model based on the Global Green Economy Index (GGEI) revealed significant problems and lagging, especially in comparison with the EU countries (30th place out of 38 European countries in 2005 and 33rd place out of 38 European countries in 2023), as well as an adequate basis for accelerating the transition. The study notes the existence of an established legislative and regulatory framework for the transition of the national economic system and the agricultural sector to a circular green model of development.

Based on the study of scientific developments, the study identified the benefits of transition to a circular green model of agribusiness development in Ukraine for the national economy, agricultural producers, society and households. Separately, based on the Ishikawa Diagram, the cause-and-effect relationships of the issues of transition to a circular green model of agribusiness development in Ukraine were formed, with six groups of key problems identified (institutions, society, markets, technology, personnel, and finance). At the end of the study, the authors formulated ways to reform the Ukrainian agribusiness to ensure the transition to a circular green model of development, which is of practical value for state institutions, the country's agro-industrial complex and Ukrainian agricultural enterprises.

Prospects for further research in the field of ensuring the transition of Ukrainian agribusiness to the CDM are formation of mechanisms for the transition of agricultural enterprises of various sizes to the circular green development model; identification of the most promising areas for the implementation of foreign experience, primarily that of the European Union, to stimulate Ukrainian agribusiness in the framework of the transition to the circular green development model.

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Юлія Перегуда
Доктор економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
Міжрегіональна Академія управління персоналом
03039, вул. Фрометівська, 2, м. Київ, Україна
https://orcid.org/0000-0002-1434-2509

Трансформація аграрного бізнесу України в умовах переходу на циркулярну зелену модель розвитку

Анотація. Пошук шляхів для розвитку українського агробізнесу в умовах переходу економічних систем різного рівня на циркулярну зелену модель розвитку є актуальним та критично важливим завданням для підвищення рівня національної та продовольчої безпеки, а також забезпечення стійкого зростання національної економіки. Метою наукової роботи було формування напрямів прискорення переходу українських аграрних підприємств на циркулярну зелену модель ведення бізнесу на основі виявлення тенденцій та проблем розвитку агропромислового комплексу країни, визначення особливостей переходу України на циркулярну зелену модель, а також ідентифікації переваг та проблем, що супроводжують процес переходу агробізнесу на циркулярну зелену модель розвитку. Дослідження базувалося на комплексному використанні таких методів, як: літературного аналізу; збору та аналізу даних (кабінетне дослідження); бібліографічного методу; компаративної (порівняльної) оцінки; економічного аналізу; Діаграма Ісікави; систематизації, групування і логічного узагальнення. В результаті дослідження було виявлено необхідність використання агропідприємствами циркулярної зеленої моделі розвитку в межах переходу економічних систем на постіндустріальні принципи ведення бізнес-діяльності. Економічний аналіз дозволив виділити тенденції та проблеми розвитку агропромислового комплексу України, а також проблеми, що супроводжують країну в межах переходу на циркулярну зелену модель розвитку. В результаті дослідження виявлено позитивні сторони переходу українських аграрних підприємств на циркулярну зелену модель розвитку. Окремо, за допомогою використання Діаграми Ісікави, було визначено причино-наслідкові взаємозв'язки проблематики переходу на циркулярну зелену модель розвитку агробізнесу України, де було виділено шість груп проблем (інститути, суспільство, ринки, технології, персонал, фінанси). Запропоновано шляхи реформування аграрного бізнесу України в межах забезпечення переходу на циркулярну зелену модель розвитку. Отримані в ході дослідження результати мають високу практичну значимість для виробників аграрної продукції України, оскільки вони дозволяють агровиробникам прискорити перехід на циркулярну зелену модель розвитку та підвищити конкурентоспроможність і стійкість економічним викликам

Ключові слова: екологія; економіка; конкурентоспроможність; постіндустріальний перехід; ресурси; реформування

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Olena Lemishko*
Doctor of Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-6216-652X

Inna Lazaryshyna
Doctor of Economic Sciences, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-1183-7530

Anatolii Fursa
PhD in Economic Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0001-6518-5286

Crisis management of an enterprise in the context of modern challenges

Abstract. The study aimed to identify the peculiarities of enterprises' response to crisis challenges and analyse adaptation practices on the example of Ukrainian and international companies. The study addressed the Ukrainian companies Nova Poshta, Kernel, Rozetka and DTEK. The study used the method of contextual analysis to analyse political, economic, social and technological factors of enterprise development, as well as benchmarking, which consisted of comparing Ukrainian companies with European or American companies of similar profile. The analysis determined that Nova Poshta has effectively adapted to the new conditions by expanding its operating network and promptly resuming operations in the de-occupied territories. Kernel has relocated its assets to the western regions of Ukraine, combining this process with support for specialists working in the occupied and de-occupied territories. Rozetka has stabilised economic performance by refocusing on Ukrainian producers and introducing promotional programmes to maintain its customer base and attract new customers. DTEK, in turn, is overcoming the crisis challenges by investing in sustainable development, as well as in staff training and retraining. The effectiveness of certain strategies, such as logistics transformation, digital innovation, human capital development and accountability, has been confirmed by the activities of leading foreign companies: Deutsche Post DHL (Germany), Cargill (USA), Enel Group (Italy) and Amazon (USA). Based on the comparative analysis, the study suggested that Ukrainian enterprises should implement the principles of social

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*Corresponding author

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responsibility, increase investments in infrastructure and human capital, as well as diversify production and manage risks. The practical significance of the study is determined by the possibility of using the proposed strategies to increase competitiveness and ensure sustainable development of enterprises under conditions of uncertainty

Keywords: sustainability; sustainable development; benchmarking; social responsibility; strategic planning

INTRODUCTION

Being in a state of full-scale war has a significant impact on Ukraine's economic development. The outflow of population, reduction in consumption, and, consequently, production increased unemployment and decreased the quality of life of the population. In the context of economic downturn and uncertainty, crisis management of enterprises is of particular importance, as it is aimed to ensure sustainable economic development.

The reduction in the scale of operations resulted in a drop in tax revenues, job losses, an outflow of skilled workers, and reduced chances for economic recovery in the post-war period. According to I. Myagkykh & T. Demyanenko (2024), a gradual recovery of business activity is possible thanks to government support and international initiatives, in particular from the European Union (EU). The researchers noted that international assistance is a source of funding in times of uncertainty, a basis for implementing sustainable development projects, and an incentive for creating new businesses.

R. Grinchenko & S. Lukinov (2024) emphasised that further sustainable development is possible through crisis management, which is based on analysis of the barriers to doing business in an uncertain environment. Among such barriers, the authors highlighted insufficient support for entrepreneurial activity by local authorities, unfavourable conditions for lending to production, a complicated procedure for obtaining permits and a monopoly on the part of large enterprises. As noted by Oleshko *et al.* (2020), the investment crisis in Ukraine was observed even before February 2022. With the outbreak of the war, the situation became more complicated: due to economic uncertainty, enterprises face difficulties in attracting credit, attracting investors, and obtaining grant funding.

According to A. Zainab Ibrahim (2024), the philosophy of crisis management has become widespread in world practice. The study noted that the key goal of such management is both to prevent the occurrence of crises or factors that provoke them and to minimise the consequences of existing or imminent crises. M. Attar & A. Abdul-Kareem (2023) emphasised the link between crisis management and sustainable development of enterprises under conditions of uncertainty. The highlighted link is moderated by strategies aimed to adapt to the changed business environment, as well as exploring and maximising the benefits of emerging opportunities. O. Erdeli (2024) noted that certain crisis management strategies, such as crisis communication, increase the level of trust on the part of stakeholders and lay the groundwork for further effective interaction. Trust grows if employees, customers and other stakeholders are aware that the company is doing everything possible to provide them with timely and objective information to make effective strategic decisions. A. Maceika *et al.* (2024) surveyed 30 representatives of Lithuanian companies and concluded that, despite the numerous advantages, the use of crisis management strategies is not fully implemented or not at all. The obstacles to the use of such strategies included, in particular, a lack of awareness of crisis management strategies and a lack of experience in their implementation.

According to J. Moustakim & B. Mohammed (2025), barriers to effective crisis management may include insufficient preparedness of employees to implement the latest technologies, such as the use of artificial intelligence to collect and process data on possible crises and strategies to overcome them. The study developed a model of digital literacy empowerment and well-being that can be used to effectively overcome cognitive, emotional and psychological

barriers to the implementation of enterprise crisis management strategies. The analysis of 32 scientific sources, including 29 on crisis management during the coronavirus pandemic, conducted by D.H. Abdul Rezak *et al.* (2024), concluded that the reason for the lack of effective crisis management is the lack of professional knowledge. D.H. Abdul Rezak *et al.* emphasised the need for further research to gain a detailed notion of the factors leading to enterprise crisis and relevant strategies for responding to these factors. A similar opinion was expressed by Z. Ciekanowski *et al.* (2024), highlighting the lack of scientific research on strategies that ensure the sustainable development of enterprises in times of crisis. According to Z. Ciekanowski *et al.*, the effective implementation of crisis management largely depends on awareness of the technologies that can support such management, as well as research into the human aspects of the crisis, in particular, psychology and organisational culture. K. Klyver & S.L. Nielsen (2024) suggested that the lack of awareness of crisis management strategies is due to the fact that crisis phenomena are complex in nature, as they occur not only in economic but also in cultural and other dimensions. Based on a longitudinal representative dataset of Danish small and medium-sized enterprises for the period from 2015 to 2020, K. Klyver & S.L. Nielsen concluded that crisis preparedness is critical to the strategic choices of enterprises and should take place long before a potential negative event. Thus, preparing for a crisis requires extensive research at the stages of financial, organisational and cultural planning.

Based on the analysed sources, crisis management of enterprises in the context of modern challenges is an insufficiently researched topic. Although there is a sufficient number of scientific sources discussing the prospects and benefits of crisis management in enterprise management, studies of strategies to overcome these barriers are few and far between. Given these gaps, the study aimed to analyse strategies for effective crisis management under conditions of uncertainty, emphasising Ukrainian economic realities. The objectives were to contextualise the factors that contribute to the choice of anti-crisis management strategies, analyse the barriers to the use of such strategies, and develop practical recommendations for overcoming them.

MATERIALS AND METHODS

The study applied a set of methods aimed to identify effective anti-crisis strategies of Ukrainian enterprises and assessing the possibilities of their adaptation to uncertainty. The content analysis method was used in the context of such Ukrainian enterprises as Rozetka. UA (2023), Kernel (2024), DTEK (n.d.) and Nova Poshta (n.d.a). The sample for the content analysis included four companies (n = 4) that meet the following inclusion criteria: operate on the Ukrainian market; demonstrate resilience, maintaining operations even in the face of significant challenges; demonstrate the ability to develop sustainably despite martial law and related restrictions; and represent key sectors of the Ukrainian economy: freight, trade, energy, and agriculture. In the sample presented, Nova Poshta was a company that successfully competes with other players in the last-mile delivery segment; Kernel is an agricultural holding with well-established agricultural processes; DTEK is an energy company whose successful operation affects the work of all other segments of the economy; Rozetka is a representative of the e-commerce segment and an example of effective implementation of crisis management.

The study also used the PEST-analysis method to identify universal political, economic, social and technological factors influencing the development of enterprises in conditions of uncertainty. In addition to these tools, the benchmarking method was also used to compare the anti-crisis strategies of individual Ukrainian enterprises with the anti-crisis approaches of European and global companies. The comparative analysis underlying the chosen method identified universal anti-crisis strategies and explored the possibilities of their implementation in the Ukrainian reality. For the benchmarking, four pairs were created, each containing one Ukrainian company and one company from Germany, the USA or Italy. The pairs were selected based on similarity in terms of the scale of operations, segments and sources of crises. Thus, the benchmarking method included the following pairs: Nova Poshta, Ukraine – Deutsche Post,

Germany (DHL Group, 2024); Kernel, Ukraine – Cargill (2024), USA; DTEK, Ukraine – Enel, Italy (Enel Group, 2024); and Rozetka, Ukraine – Amazon (2024), USA. These pairs of companies were analysed according to the following key criteria: risk type, operational response, social responsibility and global expansion. Where relevant, the criteria for logistics management and participation in international initiatives were also addressed. The key objective of the benchmarking was to identify universal anti-crisis strategies that can be used to increase the resilience and ensure sustainable development of Ukrainian companies in an uncertain environment. The data obtained using mixed methods of research was used to develop strategies that would help Ukrainian companies prevent crises or minimise their impact. The recommendations were considered in the context of Kurt Lewin's model of change (Ting, 2021), which suggests that each transformation is the result of "unfreezing", directly changing, and re-freezing approaches to enterprise management.

RESULTS

Business development in uncertain times

Ukrainian businesses are developing in a highly challenging context driven by a combination of political, economic, social and technological factors. Amidst high risks, instability and limited access to traditional sources of funding, Ukrainian companies are increasingly focused on digital transformation, cost optimisation, and diversification of suppliers and partners. In addition, the role of human capital, sustainable communications, and flexible management models is growing. To make strategic decisions, it is necessary to consider the impact of the external environment, which was analysed using the PEST analysis method presented in Table 1.

Table 1. PEST-analysis of the development of Ukrainian enterprises

Factor	Characteristic
Political	■ Russia's military aggression poses risks to logistics, energy and agriculture; ■ Government support for exporters, logistics companies and the IT sector; ■ Anti-corruption reforms, EU integration.
Economical	■ High inflation and hryvnia devaluation; ■ Refocusing on exports and digital transformation; ■ Government lending programmes (5-7-9) and support for small businesses.
Social	■ High level of labour migration and mobilisation; ■ Increased civic engagement and demand for ethical business; ■ Growth of online consumption, new consumer habits.
Technological	■ Rapid development of digital services (payments, marketplaces, automation); ■ Investments in renewable energy sources and smart energy metering systems; ■ Cybersecurity as a priority.

Source: compiled by the authors based on Y.M.H. Hazaa *et al.* (2021), L.D. Parker (2023), Diia (2023)

Table 1 shows that the key political factor affecting the functioning of Ukrainian enterprises is the Russian military aggression, which creates risks for logistics. Ukrainian companies are forced to adapt to these changed conditions, in particular, by relocating production lines and changing logistics in the frontline and de-occupied regions. An example of rapid adaptation to the changed conditions of business management is Nova Poshta, a delivery company that opened in 2001 as a branch with 7 employees and later transformed into a network of 500 branches and a team of more than 5,000 people In 2022, Nova Poshta delivered 315 million parcels and 2.6 million tonnes of cargo, which was only 15% less than in pre-war 2021. Starting in 2022, Nova Poshta tried to minimise the risks of military aggression by relocating some of its branches to safer locations and opening branches abroad. As of 2024, there were 4 Nova Poshta branches in the Czech Republic alone, which helped to establish international logistics. Despite the risks, the company delivers parcels to the de-occupied territories and opens new branches and post offices in the frontline areas, including Izyum, Staryi Saltiv, Kharkiv, Sviatohirsk and Lyman. In

2024, Nova Poshta opened 350 such branches and post offices, which demonstrates the company's potential for sustainable development despite political challenges (Nova Poshta, n.d.b).

The analysis also revealed an unfavourable economic context for the operation of enterprises, which is manifested through high inflation, hryvnia devaluation and a decrease in the solvency of the population. Online retailer Rozetka was one of the companies that suffered significant economic losses after 24 February 2022 and was forced to revise its management strategies to adapt to the changed reality. Starting in February 2022, the company recorded a significant decrease in monthly turnover from 4 billion UAH to 23 million UAH. Due to the decline in turnover, the company could not fully fulfil its obligations to suppliers and was forced to lay off some of its staff. Inflation and the devaluation of the Ukrainian currency also led to higher prices for imported goods, forcing the company to refocus on domestic production. This reorientation resonated with the company's target audience, which saw an intensification of patriotic sentiment, including through increased readiness to support the Ukrainian manufacturer. Rozetka has also tried to adapt to the changed economic environment by adopting the following strategies: creating a Super Price section with constantly updated products with maximum discounts; introducing a cashback and bonus programme, including Rozetka Premium, to encourage regular purchases; and holding periodic sales. During sales such as Black Friday, the number of shoppers increases by 50% and the demand for domestically produced goods by 70%. Thus, Rozetka is an illustration of the economic challenges faced by Ukrainian businesses and an example of how to adapt to these challenges for sustainable development (Rozetka.UA, 2023).

The impact of social factors is also significant, as they can act as both obstacles to the functioning of Ukrainian enterprises and drivers for their effective management. According to the results of the PEST analysis, the unfavourable factors include high migration, mobilisation, and a shortage of skilled personnel (Terebukh & Roik, 2024). The category of favourable factors includes increased civic engagement, conscious consumption, support for Ukrainian producers, and the emergence of new consumer habits such as online shopping. Energy company DTEK is an example of an enterprise that is trying to take advantage of the opportunities associated with social factors while minimising the risks. Despite the challenges of a full-scale military aggression against Ukraine, DTEK continues to invest in the country's renewable energy sector, thus supporting its sustainable development. By October 2025, the company plans to complete the construction of 200 MW of flexible energy storage systems and increase the capacity of the Tiligul wind farm to 500 MW (DTEK, n.d.). To these initiatives, it is worth adding the creation of 5 GW of renewable energy capacity in European countries such as Italy, Romania, Poland and Croatia by 2030. DTEK's management is also aware and attempts to minimise the negative impact of social processes such as migration and the lack of qualified personnel. Since 2019, DTEK has been a member of the Business Without Barriers community and has been actively implementing the dual education model (Diia, 2023). Dual education provides barrier-free access to the energy profession and a guarantee of a job after graduation. This initiative was used by DTEK to popularise the energy profession, attract motivated personnel and lay the groundwork for long-term cooperation.

In addition to the above, the operation of Ukrainian enterprises is influenced by technological factors, such as the development of digital services, investments in smart technologies, and cybersecurity. Most of these factors can be viewed as incentives for adaptation and sustainable development of Ukrainian businesses in the face of uncertainty. Kernel Agricultural Holding is an example of a company that successfully uses the latest technologies to avoid or minimise the negative impact of risks. The company's specialists, in particular, have developed and implemented the DigitalAgriBusiness system, an internal pharmaceutical management system that combines data from laboratory soil analysis, satellite images, meteorological indicators and field surveys (Kernel, 2024). The system provides companies with access to

various types of information, including laboratory soil data, satellite images, meteorological data and field surveys, which can be used to rationally allocate available resources and minimise potential risks. This system provides accurate planning of agricultural technologies and yield forecasting. The company also uses simulation modelling capabilities to optimise transport routes and simultaneously manage hundreds of facilities to effectively manage the supply of products. Kernel Ukraine implemented the DigitalAgriBusiness system back in 2018, and in its first year of operation, it added 25 million USD to the company's overall Earnings before Interest, Taxes, Depreciation and Amortisation (Kernel, 2024). As of 2025, the value of the presented system is the optimisation of logistics and delivery of products even to remote areas, de-occupied territories or frontline zones.

Thus, the contextual analysis revealed that Ukrainian enterprises are developing in a challenging environment of full-scale Russian military aggression, economic downturn, mass migration and rapid technological change. The companies included in the sample have demonstrated the ability to adapt to new realities and maintain sustainable development despite uncertainty. However, the recovery and increase in production volumes require further strategic planning, including risk management.

The response of enterprises to crises and risks: comparative case analysis

The comparative analysis identified crisis management strategies of enterprises in different segments of the economy. The comparative analysis addressed the fact that the key risk for all Ukrainian companies was the hostilities and related restrictions. In contrast to Ukrainian companies, German, Italian and American companies did not face martial law restrictions in their operations. German, Italian and US companies faced economic crises, population outflows and competition, which made comparisons with Ukrainian companies reasonable.

Founded in 2001 as a small branch, Nova Poshta quickly transformed into Ukraine's largest express delivery network. In 2024, Nova Poshta demonstrated its ability to grow sustainably, increasing the number of shipments by 16% and growing revenue by 22% to 44.77 million UAH (Pikalo, 2025). The company's net profit decreased by 36.9% compared to the previous year, which showed the need to implement anti-crisis management strategies. In the same reporting period, Deutsche Post declared a 3% increase in revenue to 84.186 billion EUR, but net profit decreased by 9.4% compared to 2023 (DHL Group, 2024). The results of the comparison of Nova Poshta and Deutsche Post DHL's crisis management are presented in Table 2.

Table 2. Comparative analysis of the crisis management of Nova Poshta and Deutsche Post DHL

Criteria	Nova Poshta (Ukraine)	Deutsche Post DHL (Germany)
Type of risk	Military operations, infrastructure threats	Economic challenges, inflation, and competition
Operational response	Quick resumption of work, mobile offices, mini-bomb shelters	Reduce staff, optimise costs
Social responsibility	Humanitarian aid, business support, and delivery to the de-occupied territories	Global humanitarian missions
Innovations	Use of Starlink, mobile offices, and adapting logistics to war conditions	Investments in digitalisation, optimisation of logistics processes
Global expansion	Opening of branches in Poland, Lithuania, Germany, the Czech Republic, Romania, France, Italy, Spain and the UK	Presence in over 220 countries, focus on international logistics and express delivery

Source: compiled by the authors based on DHL Group (2024), Nova Poshta (n.d.b)

Table 2 shows that Nova Poshta is highly adaptable to unstable conditions, including during war, by implementing innovative solutions, mobile offices and humanitarian support programmes. Its response to risks is locally focused, aimed to preserve infrastructure and supporting the population. Deutsche Post DHL, on the other hand, focuses on strategic,

long-term global risk management, including through cost reduction, automation and the development of international partnerships. Both companies demonstrate effective, but different approaches to risk management in line with the specifics of their markets and challenges.

The status of Ukraine's largest agricultural producer and exporter does not make Kernel insensitive to the challenges of wartime. In the fourth quarter of 2024, the company declared a 44% drop in net income compared to 2023 (Kernel, 2024). The decrease in net income, which occurred against the background of a 3.7% increase in revenue compared to the previous reporting period, was due to unfavourable market conditions and force majeure. The American company Cargill also found itself in a similar economic situation, declaring a 10% decrease in net income in 2024 compared to 2023 (Cargill, 2024). Having experienced a decline in revenue to 160 billion USD, the company was forced to cut 5% of its staff, which equated to 8,000 employees. Thus, both companies need to implement anti-crisis strategies to increase their resilience in the face of uncertainty. A comparative benchmarking analysis of Kernel and Cargill was also conducted, the results of which are presented in Table 3.

Table 3. Comparative analysis of the Kernel and Cargill crisis management

Criteria	Kernel (Ukraine)	Cargill (USA)
Type of main risks	Military operations, blockade of ports, disruption of logistics, destruction of infrastructure	Geopolitical tensions, inflation, supply chains, regulatory constraints, and challenges to renewable energy
Operational response	Relocation of assets to the western regions, digitalisation of agricultural production, investments in railway logistics	Portfolio diversification, investments in infrastructure in Latin America and Africa, and localisation of production
Innovations	Kernel Digital, AI/ML for yield forecasting, automated elevators, eTTN	Cargill's innovation hub, Cargill Digital Labs, blockchain in cocoa and grain supply
Social responsibility	Support for farmers in the de-occupied territories, humanitarian initiatives, and transparency of expenditures	Programmes to help farmers in developing countries reduce emissions and respect workers' rights
Logistics management	Creation of alternative routes through the Danube and Romanian ports, development of transit via railways	Internal fleet of barges and vessels, global network of warehouses, agreements with Maersk, investments in agro-logistics in Brazil
Financial sustainability	Temporary decline in revenue in 2022–2023, but productivity gains due to optimisation	Record profit in 2023, strong cash flow and global presence in more than 70 countries
Renewable energy and sustainable development	Priority on transparent reporting, reduction of CO_2 emissions, and local soil restoration programmes	Aggressive sustainable development strategy: Cargill Climate Goals, decarbonisation of logistics, sustainable supply chain

Source: compiled by the authors based on Kernel (2024), Cargill (2024)

Based on the results of the analysis, it is possible to conclude that Kernel demonstrates resilience in the face of military risk, relying on digital transformation, logistics flexibility and support for agricultural producers. The company is focusing on internal adaptation and maintaining its export potential in the face of limited access to ports. Cargill, as a global agricultural giant, uses broad diversification, digital tools and ESG (Environmental, Social, and Governance) initiatives to mitigate risks in global markets. Their strategies differ in scale and nature, but both companies demonstrate strategic flexibility and technological innovation in their approaches.

For the Ukrainian energy company DTEK, 2024 was a productive year from a financial point of view, as it recorded an increase in net profit: from 618 million UAH in 2023 to 738 million UAH in 2024 (DTEK, n.d.). Progress was also observed in the renewable energy segment, where net profit in 2024 reached 1.584 billion UAH, while in 2023 the company recorded a loss of 547 million UAH. In contrast to DTEK, Enel recorded a 17.4% decline in consolidated revenue: from 95.656 billion EUR in 2023 to

78.947 billion EUR in 2024 (Enel Group, 2024). This drop could be due to lower energy volumes and prices, as well as the sale of assets in Romania and Peru. Thus, both companies are forced to develop in an uncertain environment that requires careful crisis management. The results of the DTEK and Enel benchmarking are shown in Table 4.

Table 4. Comparative analysis of DTEK and Enel crisis management

Criteria	DTEK (Ukraine)	Enel (Italy)
The context of the crisis	War, energy instability, infrastructure destruction, and limited access to resources	Energy crisis in Europe, high gas prices, geopolitical risks, transition to renewable energy sources
Operational measures	Backup power supply Evacuation of personnel Fast repair of power grids Centralised management of emergency teams	Backup power supply Evacuation of personnel Fast repair of power grids Centralised management of emergency teams
Financial management	Anti-crisis loans State and international assistance Cost optimisation Raising donor funds	Reorientation of investments to sustainable projects Flexible pricing policy Reducing the debt burden
Personnel management	Protection of employees in combat zones Psychological support Remote work whenever possible	Training programmes on working in times of crisis Upskilling for the transition to green energy
Communication strategy	Transparent reporting to the public Constantly informing the public Cooperation with the state and volunteers	Active communication with consumers Sustainability reporting Interaction with European institutions
Innovative solutions	Pilot projects for autonomous power supply (solar generators, mobile batteries) Smart solutions for rapid response	Large-scale implementation of digital platforms Smart Grid, Predictive Maintenance Development of electric vehicle infrastructure
Participation in international initiatives	Support from the EBRD, USAID, and the EU Cooperation with the UN in the field of energy sustainability	Participation in EU initiatives (REPowerEU, Fit for 55) Global climate partnerships
Resilience to future crises	Emphasis on decentralisation and capacity redundancy	Focus on digitalisation, decarbonisation and energy autonomy

Note: EBRD – European Bank for Reconstruction and Development, EU – European Union, UN – United Nations
Source: compiled by the authors based on I. Gernego *et al.* (2022), Enel Group (2024), DTEK (n.d.)

The analysis (Table 4) concluded that both companies demonstrate a high level of adaptability to crisis conditions, but their strategies reflect different national challenges: DTEK is focused on ensuring an uninterrupted power supply in the face of war and destruction. Starting in February 2022, DTEK shifted its funding from development projects to prioritise the restoration of damaged generation and created a network of crisis management headquarters to coordinate repair teams, including in frontline areas. Enel, in turn, emphasised resource diversification and digital transformation in the context of the European energy crisis. DTEK is actively applying operational solutions to quickly restore infrastructure and attract international support, while Enel is investing in sustainable development and innovation to ensure long-term sustainability. Both companies prioritise communication and staff support, adapting their management models to the specifics of local crises.

Online retailer Rozetka managed to reverse the financial decline caused by the outbreak of full-scale military aggression in 2022, and in 2024, the company recorded a 48% year-on-year increase in revenue compared to 2023 (Forbes, 2025). To adapt to the generally unfavourable business environment, Rozetka reformed its delivery network, closing its largest store near Pochayna metro station in Kyiv in June 2024 and opening 125 small delivery points

instead. For the US-based Amazon, 2024 was also a successful year from a financial point of view, as total sales grew by 11% and net profit increased by 95%, from 30.4 billion USD in 2023 to 59.2 billion USD in 2024 (Amazon, 2024). The resilience of selected online retailers in the face of economic uncertainty is attracting interest in their crisis management strategies. The results of the comparative benchmarking of Rozetka and Amazon are documented in Table 5.

Table 5. Comparative analysis of Rozetka and Amazon crisis management

Criteria	Rozetka (Ukraine)	Amazon (United States)
The context of the crisis	War in Ukraine, logistical disruptions, falling purchasing power	Global supply chains, COVID-19 pandemic, inflation, geopolitical risks
Operational measures	Mobilisation of stocks of goods Redirecting logistics routes Implementation of contactless delivery Local cooperation with suppliers	Supplier diversification Warehouse automation Supply chain optimisation Implementation of artificial intelligence for demand forecasting
Financial management	Revision of the credit policy Optimisation of marketing costs Attracting investments to maintain liquidity	Investing in infrastructure and technology Flexible capital management Reducing the cost of operations
Personnel management	Ensuring the safety of employees in crisis conditions Flexible work schedules Motivation through bonuses	Health and well-being programmes Large-scale training and retraining Support for remote work
Communication strategy	Active informing of customers about changes Support through social media and the call centre Cooperation with government agencies	Transparent information about the availability of goods and delivery Loyalty programmes Active PR campaign to maintain the image
Innovative solutions	Implementation of CRM systems to improve service Online payment and mobile application Warehouse automation	Use of robots and artificial intelligence in warehouses Development of internal logistics technologies (drones, autonomous trucks) Using artificial intelligence to personalise offers
Participation in international initiatives	Limited due to local focus, but cooperation with international payment systems	Active participation in global environmental, social and governance initiatives
Resilience to future crises	Flexibility in logistics, quick response to local changes, and development of e-commerce	Large-scale infrastructure, technological superiority, and diversification of business models

Note: PR – Public relations, CRM – Customer relationship management
Source: compiled by the authors based on Rozetka.UA (2023), F. Aissaoui & M. Elhazzam (2021), Amazon (2024)

Based on the analysis (Table 5), Rozetka and Amazon demonstrate effective anti-crisis strategies adapted to different scales and market conditions: Rozetka prioritises rapid response in the context of war and logistical challenges in Ukraine, ensuring the smooth operation of the platform and support for local partners. Amazon, with its global scale, focuses on innovation, automation and supplier diversification to maintain supply chain stability. Both companies place a strong emphasis on employee safety and customer communication, but Amazon has the greater resources to invest heavily in technology, responsible management and sustainability initiatives.

Thus, operating in the context of political and economic uncertainty requires companies to conduct crisis planning aimed to prevent certain undesirable events or minimising their negative impact. A comparative analysis of Ukrainian, American, Italian and German companies has shown that effective anti-crisis strategies include mobilising resources, changing logistics, increasing investment in innovative solutions and participating in international initiatives. These anti-crisis strategies

are universal, as they demonstrate their effectiveness regardless of the political, economic or socio-cultural context.

Implementation of crisis management strategies for enterprises under conditions of uncertainty

Based on the analysis, a set of recommendations for effective crisis management of enterprises in the context of uncertainty was developed. Ukrainian enterprises facing new challenges were suggested to increase their operational flexibility and speed of response. Based on the results of the benchmarking analysis, operational flexibility and responsiveness depend on several factors, including the ability to install a backup power supply, implement a mobile office system, and relocate assets in case of danger. The effectiveness of these actions has been confirmed by the practical experience of companies such as DTEK (n.d.), Nova Poshta (n.d.a) and Kernel (2024). The experience of Rozetka.UA (2023) also led to the conclusion that operational flexibility and rapid response can be ensured by redirecting logistics and ensuring contactless delivery, especially in conditions where large crowds are a potential source of threat. The opening of 125 new Rozetka delivery points in 2024 alone proves that it is possible to revise the logistics network even in emergency martial law conditions. In turn, the experience of DHL Group (2024) and Cargill (2024) shows that operational flexibility and, consequently, sustainable development of enterprises can be ensured by optimising resources and localising production. The layoff of 8,000 employees provided additional resources for sustainable development in the context of the economic downturn in the agricultural segment.

The effectiveness of crisis management in enterprises can also be significantly improved through innovation and digital transformation. The experience of companies such as Cargill and Enel highlights that the introduction of artificial intelligence, smart grids, etc., is a relevant transformation. Online retailers are implementing the philosophy of digital transformation, including through warehouse automation and the use of mobile applications. The cases of Ukrainian companies Kernel and Nova Poshta also show that transformation processes can take the form of alternative logistics and digital platforms, which reduce the cost of delivering components or goods and increase their speed. The example of Nova Poshta demonstrates that changes in logistics, including through the creation of mini-hubs and a gradual reduction in the load on the central terminal, can reduce the cost of a parcel by 8-12%, thus increasing the attractiveness of the service for existing and potential customers (Nova Poshta, n.d.b). In some cases, such as the management of enterprises in frontline areas, the development of alternative logistics is a key to resilience and sustainable development. These examples highlight that technology can be used to effectively manage risks, anticipate changes in demand, and maintain competitiveness in the face of uncertainty.

Companies that are forced to operate in an environment of uncertainty are also encouraged to diversify their risks, including by expanding their geographic presence, localising production and creating alternative routes. The effectiveness of the recommendation to diversify risks has been proven by the experience of companies such as Cargill, Amazon and Nova Poshta. At the same time, the cases of Deutsche Post DHL and Rozetka prove that risk minimisation is possible through diversification of suppliers and transport solutions. The experience of Rozetka and Amazon highlights that diversification of the logistics network can increase the net profit of companies by 48%-95%. In the face of uncertainty, focusing on an internal supplier proved to be an effective solution as a way to reduce the cost of a product or service and meet the target audience's need for a socially oriented business. Based on the above recommendation, it is possible to conclude that the distribution of risks between regions, supply channels and partners is the basis of a company's resilience to global crises.

The results of the benchmarking analysis also led to the conclusion that an effective anti-crisis approach involves human resource management and support for human capital. The cases of DTEK, Amazon and Enel show that effective HR management tools as part of an enterprise's anti-crisis philosophy include the introduction of flexible work schedules, psychological

assistance to employees and investment in staff training and retraining. The experience of Rozetka and Enel underlines the importance of workplace safety and support for various training initiatives in times of crisis. Investing in training and retraining can bring long-term economic benefits, as it reduces the probability of errors, improves the quality of goods or services, and lays the groundwork for long-term cooperation between the company and its employees. The importance of investing in long-term cooperation was demonstrated by DTEK, which lost about 5,000 employees in 2024, mainly due to mobilisation processes (DTEK, n.d.). As of 2025, the Ukrainian energy company faces the task of filling existing vacancies, including by creating favourable working conditions for graduates of secondary and higher education institutions. Thus, this recommendation is based on the idea that investing in staff and caring for their well-being increases employee loyalty and reduces losses in times of crisis.

The benchmarking of enterprises also formed the basis for the recommendation to introduce effective communication and reputational sustainability of enterprises, especially in the face of new challenges. An analysis of DTEK and Nova Poshta's experience shows that effective communication implies transparency of the company to the public, as well as active cooperation with the state and volunteers. Examples of companies such as Amazon and Rozetka prove that effective communication requires companies to be accountable, create loyalty programmes and constantly inform their target audience about the availability of goods. The recommendation to improve communication effectiveness and reputational resilience is based on the notion that open communication builds trust among consumers and partners, which is especially relevant in times of uncertainty and crisis.

In addition to the recommendations already mentioned, it was also proposed to strengthen the crisis management of enterprises by ensuring their sustainability and social responsibility. The experience of Cargill, Enel and Nova Poshta demonstrates that this recommendation can be implemented through the implementation of programmes to support local communities and adherence to the principles of responsible business. The cases of DTEK and Kernel, in turn, emphasise that companies' readiness for sustainable development and social responsibility is manifested in the form of initiatives to restore infrastructure, reduce emissions and increase cost transparency. This recommendation emphasises that social responsibility and environmental sustainability increase public trust in a company and help build its long-term reputation.

Each of the proposed recommendations can be implemented using Kurt Lewin's model, which includes three phases of the transformation process. At the first stage of transformation, there is a "defrosting", i.e. preparation of the enterprise for the implementation of crisis management. The main task of this stage is to convince the responsible persons of the need for a new approach through a detailed analysis of its short-term and long-term benefits. At the first stage of transition to crisis management, a cost-benefit analysis can be used to show that long-term benefits outweigh short-term costs. The second stage involves the direct transformation of the implementation of new strategies, approaches and tools of crisis management. At this stage, it is appropriate to organise training or retraining of specialists so that they are aware of the nature of the changes and have sufficient skills to implement them. At the "re-freezing" stage, it is necessary to ensure the long-term effect of the transformation by consolidating new strategies and approaches at the level of enterprise management. The company's readiness for crisis management can be declared, for example, in the company's charter or job description.

DISCUSSION

Crisis management is the key to the resilience and sustainable development of enterprises in the context of uncertainty. This idea was considered in the context of Nova Poshta, Kernel, Rozetka and DTEK, which, starting from 24 February 2022, suffered losses and were forced to adapt to the changed realities. The benchmarking analysis demonstrated that the companies were able to successfully adapt to the changes and demonstrate their readiness to return to pre-war capacities. The idea of the link between crisis management and resilience

in times of uncertainty presented in this paper has been confirmed in previous studies, including C.G. Ugwuja (2024). After examining various types of crises, including natural, technological and human-induced crises, Ugwuja concluded that risks and preparedness to respond have a positive impact on key components of organisational resilience such as anticipation, adaptability and renewal. A.S. Alsehbami (2025) analysed statistical data from 301 micro and small enterprises and concluded that crisis preparedness, which involves the use of crisis management strategies, increases the adaptive capacity of the enterprise. Thus, the preliminary studies emphasise the idea presented in this paper that the implementation of anti-crisis management strategies ensures the sustainability of an enterprise in even the most unfavourable situations.

The study also explored the idea that contextual factors influence the choice of anti-crisis management strategies. The PEST analysis demonstrated that Ukrainian enterprises are forced to operate and develop in a predominantly unfavourable political, economic and social environment. A detailed analysis of these conditions, however, is crucial for creating effective strategies to prevent or minimise the negative effects of crises. This idea was confirmed in early studies, for example, by M.F. Harake (2024), analysing how well enterprises are adapted to function in changed circumstances. According to M.F. Harake, the effectiveness of organisational management can be determined, among other things, by the presence or absence of a contingency plan. The presence of such a plan indicates the strategic focus of the enterprise and its readiness for long-term development, despite external circumstances. According to the analysis of Y. Jin *et al.* (2024) on the results of a survey of 30 experts in the field of crisis communication, readiness for challenges has become the philosophy of modern crisis management. Y. Jin *et al.* emphasised that the focus has shifted from reacting to a crisis to preventing it. The importance of the changed focus was proved in the context of the strategies of such Ukrainian companies as DTEK, Kernel, Nova Poshta and Rozetka. The contextual analysis showed that these companies were partly prepared to operate in the context of uncertainty, so they adapted to the changed realities relatively quickly. Further benchmarking analysis revealed that the experience gained by these companies is unique, as in contrast to their European or American competitors, Ukrainian companies are forced to continue their development in a context characterised by several political, economic, social and technological challenges, most of which are caused by full-scale military operations in the country.

The idea of the study regarding the importance of communication as an anti-crisis strategy is also reflected in previous studies, in particular, by O. Ridheta Citrawijaya *et al.* (2024). After analysing cases from the finance, healthcare and technology sectors, O. Ridheta Citrawijaya *et al.* concluded that timely, transparent and responsive communication is key in managing public perception and minimising damage to the company's reputation. An example of transparent and open communication is the retailer Rozetka, which analysed the patriotic sentiments of its audience and successfully integrated them into a communication campaign that reoriented the company towards domestic production. M. Ivanova *et al.* (2024) highlighted that the development of creative potential helps enterprises to quickly adapt to crisis challenges. The study emphasised that a creative approach to crisis management contributes to finding innovative solutions and increases the company's resilience in the face of change. A. Wajahat (2024) also confirmed the importance of transparent communication as an effective strategy for crisis management. In contrast to the presented work, where productive communication is considered only in terms of timeliness and transparency, A. Wajahat expanded the criteria to include perception management, coordinated interaction, and strong leadership. F.K. Hassooni & S.H.J. Al-Naffakh (2023), in turn, emphasised the role of political communication in managing crisis phenomena in the enterprise.

The study also examined the relationship between the social responsibility of enterprises and their crisis management strategies. The social responsibility strategies considered in this paper include, in particular, the creation of anti-crisis headquarters by DTEK, programmes to support the health and welfare of employees by Amazon and training programmes for the

transition to renewable energy sources by Enel. The importance of social orientation as an anti-crisis management strategy was studied by other experts, in particular, A. Chopra & P. Sharma (2025), in an analysis of data from a survey of 200 business leaders. According to A. Chopra & P. Sharma, the integration of the philosophy of social responsibility into crisis management is manifested through the willingness of enterprises to demonstrate their commitment to moral behaviour, resilience and sustainable development. J. Hwang (2024) emphasised that social orientation as part of the crisis strategy is effective in restoring the company's reputation during the crisis. This opinion can at least partially explain how Rozetka's reorientation helped the company retain customers and compensate for the losses caused by the reduced solvency of its target audience. According to S.D. More & M. Bhople (2024), social orientation implies timely communication and full information about the crisis to maintain stakeholder loyalty. Such a manifestation of social orientation was, in particular, noticed in the strategy of Nova Poshta, which quickly informed its customers about the closure of branches in dangerous areas, their relocation or the emergence of new opportunities for receiving shipments. J. Kota *et al.* (2023) emphasised the moral aspect of social responsibility as a demand of modern consumers and other stakeholders.

Thus, correspondences were found between the conclusions and recommendations of this paper and the results of previous studies. The identified correspondences indicate that the chosen topic is relevant and sufficiently researched to ensure high-quality crisis management under conditions of uncertainty. At the same time, the presented work has made a unique contribution to the existing academic discourse by conducting a comparative analysis of crisis management of Ukrainian and international enterprises.

CONCLUSIONS

The study found that crisis management is central to ensuring the resilience and sustainable development of enterprises in the face of uncertainty, in particular in the context of a full-scale invasion of 24 February 2022. The comparative analysis revealed that an example of effective crisis management that leads to increased resilience is Rozetka, which, despite a decrease in monthly turnover from 4 billion UAH to 23 million UAH in the first months of 2022, retained its customers and achieved a 48% increase in profits in 2024 compared to the previous reporting period. Another example of resilience and sustainability was Nova Poshta, which has opened 4 new branches in the Czech Republic and 350 branches and post offices in frontline areas since February 2022. The agricultural company Kernel was able to adapt to the changes by relocating its facilities to the western part of the country and providing assistance to specialists in the occupied and de-occupied territories. As of the end of 2024, the company's turnover grew by 3.7%, which, however, did not make it immune to a 44% drop in net profit compared to 2023. The effectiveness of DTEK's crisis management is based on investing in the development of Ukraine's energy grid, active use of alternative energy sources, and training and retraining of specialists. In 2024, the energy company declared a 10% increase in profits, despite a 5,000-employee reduction in staff due to mobilisation and related processes.

The study showed that effective crisis management includes prompt response to risks, including military, economic and logistical; introduction of innovative technologies from systems focused on socially responsible business to the creation of "smart networks" for the production and sale of goods or services; and strategic communication with internal and external stakeholders. A comparative analysis with European and American companies has shown that the main anti-crisis strategies are staff reductions and cost optimisation (Deutsche Post DHL), risk diversification (Cargill), changing or creating a backup logistics network (Enel Group), and investing in innovative technological solutions (Amazon). The above crisis management strategies are universal and can be adapted by Ukrainian companies that have to operate in an uncertain environment.

A substantial component of the successful overcoming of the crises was the implementation of the principles of social responsibility and sustainable development, which was manifested in support of communities, educational initiatives,

reorientation to domestic producers, opening of branches in the de-occupied territories, and participation in international environmental and social programmes. In addition, risk distribution through supplier diversification, localisation of production, and international expansion are substantial factors for long-term sustainability. The limitation of the study is the focus exclusively on open sources and cases of large enterprises, which does not fully address the specifics of small and medium-sized businesses. Prospects for further research include expansion of the empirical base by conducting in-depth interviews and analysing crisis management strategies by sector and region in Ukraine.

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Олена Лемішко
Доктор економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-6216-652X
Інна Лазаришина
Доктор економічних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-1183-7530
Анатолій Фурса
Кандидат економічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0001-6518-5286

Антикризове управління підприємством в умовах сучасних викликів

Анотація. Метою дослідження було виявити особливості реагування підприємств на кризові виклики та проаналізувати практики адаптації на прикладі українських і міжнародних компаній. У дослідженні акцент був зроблений на українських підприємствах – «Nova Poshta», «Kernel», «Rozetka» та «DTEK». В роботі був використаний метод контекстуального аналізу, спрямованого на дослідження політичних, економічних, соціальних та технологічних факторів розвитку підприємств, а також бенчмаркінг, який полягав у порівнянні українських компаній із європейськими або американськими компаніями подібного профілю. У ході аналізу було встановлено, що компанія «Nova Poshta» ефективно адаптувалася до нових умов завдяки розширенню операційної мережі та оперативному відновленню діяльності на деокупованих територіях. Компанія «Kernel» здійснила релокацію активів у західні регіони України, поєднавши цей процес із підтримкою фахівців, які працюють на окупованих і деокупованих територіях. «Rozetka» стабілізувала економічні показники через переорієнтацію на українського виробника та впровадження акційних програм для збереження клієнтської бази й залучення нових покупців. «DTEK», у свою чергу, долає кризові виклики через інвестиції у сталий розвиток, а також у підготовку та перепідготовку персоналу. Ефективність окремих стратегій – таких як трансформація логістики, впровадження цифрових інновацій, розвиток людського капіталу та підзвітність – знайшла підтвердження в діяльності провідних іноземних компаній: «Deutsche Post DHL» (Німеччина), «Cargill» (США), «Enel Group» (Італія) та «Amazon» (США). На підставі проведеного порівняльного аналізу українським підприємствам запропоновано впроваджувати принципи соціальної відповідальності, нарощувати інвестиції в інфраструктуру та людський капітал, а також здійснювати диверсифікацію виробництва та управління ризиками. Практичне значення дослідження полягає у можливості використання запропонованих стратегій для підвищення конкурентоспроможності та забезпечення сталого розвитку підприємств в умовах невизначеності

Ключові слова: стійкість; сталий розвиток; бенчмаркінг; соціальна відповідальність; стратегічне планування

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Anatolii Olshanskyi*
Master
Donetsk State University of Internal Affairs
25000, 1 Velyka Perspektyvna Str., Kropyvnytskyi, Ukraine
https://orcid.org/0009-0001-5270-4937

Business efficiency of using "therapeutic bee beds in a pyramid" in health improvement of the American population

Abstract. The purpose of this study was to analyse the economic prospects for the development of beekeeping in the United States of America, specifically to explore the possibilities of integrating apitherapy into the agricultural sector and the wellness industry. The focus was on the effects of beekeeping on the economy, the analysis of demand for bee products, and the commercialisation potential of innovative apitherapy methods. The methodology included statistical data analysis, assessment of honey production dynamics, study of market trends, and evaluation of the economic efficiency of new bee product-based treatments. The study found that honey production in the United States in 2023 was 139 million pounds, 11% more than in 2022, despite a 6% decrease in the number of bee colonies. At the same time, the average honey yield per colony increased by 17%. The main producing states continue to be North Dakota, South Dakota, and California. Demand for honey and other bee products stays consistently high, while honey imports have fallen by 25% due to tighter product quality controls. The contribution of bee pollination to agriculture was estimated separately at over 18 billion USD annually. Particular attention was paid to the prospects for apitherapy. Analysis revealed that the market for alternative medicine and wellness services in the United States is estimated at over 1.5 trillion USD and is showing steady growth. Innovative technologies, such as the "therapeutic bee bed in a pyramid", have strong commercial potential due to the demand for natural therapeutic methods. It was estimated that the introduction of this technology in wellness centres and eco-hotels would break even within 6-12 months. The practical significance of this study lies in the fact that the findings can be used by entrepreneurs, investors, and specialists in beekeeping, alternative medicine, and the wellness business to assess the profitability of expanding business models based on apitherapy technologies

Keywords: honey; health improvement; wellness industry; medicine; bioeconomy

INTRODUCTION

Beekeeping is a prominent component of the agro-industrial complex, which not only provides honey and other products, but also plays a key role in pollinating agricultural crops. The beekeeping market is showing steady growth, but changing economic, environmental, and

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*Corresponding author

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social factors require innovative approaches to its improvement. One promising area is the integration of bee products into alternative medicine, particularly apitherapy, which not only expands the range of applications for bee products but also increases the profitability of the industry. The relevance of the present study is driven by the growing interest in natural therapeutic methods in society, the increase in demand for organic products, and the need to improve the economic efficiency of beekeeping.

The development of beekeeping as an element of the agricultural sector and its economic efficiency were the subject of the present study. Specifically, considerable attention was paid to the organisational and economic aspects of the functioning of beekeeping enterprises, the effects of the market on the profitability of the industry, and the possibilities for diversifying beekeepers' incomes through the introduction of the latest technologies and the expansion of sales markets. Various aspects of the development of beekeeping and the integration of apitherapy into the economic and tourism sectors are actively researched in scientific literature. N. Melnyk & N. Bidochko (2024) focused on the potential for the development of apitourism in Ukraine, where beekeeping could become not only a prominent part of the agricultural sector, but also a significant element of the tourism industry. This study opened new perspectives for the use of bee products for recreational and educational purposes, which may be useful for expanding activities in the wellness sector. T.O. Parfinenko (2023) examined the concept of wellness as an innovative area for the organisation of hospitality businesses. This approach contributed to the growing popularity of natural healing methods, such as apitherapy, which may become a valuable part of the hotel business offering, especially in the context of new tourism trends.

I. Svynous *et al*. (2023) covered the organisational and economic foundations of beekeeping, exploring the key factors determining the effectiveness of beekeeping activities. The researchers focused on the relationship between investment policy, marketing strategies, and the competitiveness of beekeeping products. T. Mirzoieva & L. Ilkiv (2023) addressed the risks and prospects for the development of beekeeping, analysing the effects of climate change, market fluctuations, and regulatory policy on honey production. The study demonstrated that the need to adapt to modern economic challenges is driving the search for innovative approaches to increasing the profitability of the industry.

S.A. Vinichenko (2021) highlighted the marketing aspects of beekeeping enterprises, examining the development of effective marketing strategies to increase demand for the industry's products. The researcher stressed the significance of branding, environmental certification, and participation in international markets to improve the competitiveness of beekeeping products. A study by G.L. Tyufanov (2024) on business process optimisation in agriculture was also noteworthy, as the researcher analysed the possibilities of reengineering in beekeeping. G.L. Tyufanov noted that the automation of apiaries, the improvement of logistics, and the introduction of innovative technologies can markedly increase the efficiency of honey production. A separate area of research concerns the role of beekeeping in the sustainable development of rural areas. R. Prodanović *et al*. (2024) stressed that beekeeping can be a powerful tool for stimulating regional economic development, contributing to biodiversity conservation and creating new jobs in rural areas.

A.H. Harianja *et al*. (2023) examined the global prospects for beekeeping, assessing the effects of the industry on the socio-economic status of farms. The researchers emphasised that the development of beekeeping positively influences not only on the agricultural sector, but also the environmental sustainability and food security. An interesting concept is that of apitourism as part of rural tourism development, which was explored by I. Atmazhov & A. Atmazhova (2024). The researchers considered the potential for integrating beekeeping farms into tourist routes, which could become an extra source of income for beekeepers. In the context of the economic role of beekeeping at the international level, the conclusions of O. Etxegarai-Legarreta & V. Sanchez-Famoso (2022) were important. The researchers considered the intersectoral impact of beekeeping, including its contribution to the food system,

environmental protection, and socio-cultural development of regions.

R. Sharma *et al*. (2023) outlined the practical aspects of running a beekeeping business, providing a detailed overview of apiary management methods, production profitability, and the characteristics of the honey market. A.B. Ferreira *et al*. (2023) addressed the untapped potential of the beekeeping business, emphasising that diversification of production could be a key factor in increasing the profitability of apiaries. D. Singh (2020) also considered commercial beekeeping as an industry with high profit potential, especially in the context of growing demand for natural products. M. Wakgari & G. Yigezu (2021) investigated the major constraints and future prospects of beekeeping, emphasising the need to improve technologies and market strategies.

The purpose of the present study was to analyse the economic prospects of introducing apitherapy in the United States as a factor in stimulating agribusiness and the development of beekeeping. For this, the following objectives were set: to analyse the demand for bee products and market opportunities for the development of apitherapy methods, particularly innovative technologies such as the "therapeutic bee bed in a pyramid"; to assess the profitability of apitherapy methods and their economic feasibility for businesses in the agricultural and wellness sectors.

MATERIALS AND METHODS

The study analysed data covering the 2021-2024 period. The research focused on analysing the economic potential of integrating apitherapy into the agricultural sector and wellness industry in the United States. The study was based on statistical data obtained from official sources, such as the National Agricultural Statistics Service (2023), as well as analytical reports from leading international organisations, including Grand View Research (2023) and the Global Wellness Institute (2024). Particular attention was paid to the analysis of honey market data published by the National Agricultural Statistics Service in 2023-2024, which reflected the dynamics of honey production and consumption.

The honey market analysis was based on data from the National Agricultural Statistics Service, which showed that despite a decline in the number of bee colonies in 2023, honey production increased by 11%. This was caused by an increase in the average honey yield per bee colony. The data was supplemented with information from Pasika.News (Gurman, 2022) and Gornich (International honey market..., 2022; International honey market..., 2023), which highlighted trends in honey demand in the United States, including record honey consumption in 2021 and a decline in imports driven by tighter product quality controls. Furthermore, the Gornich report contains information on the dynamics of the international honey market in 2024, which was used to understand the global context.

The analysis of the effects of bee pollination on the agricultural sector was based on data from the National Agricultural Statistics Service. According to SuperAgronom (Pollinating crops, bees..., 2020), crops such as almonds, watermelons, and apples have the greatest economic benefit from pollination. Additional data on income from renting bee colonies for pollination was obtained from the AgroPortal report (Sweeter than honey..., 2020), which described the role of commercial beekeeping in providing sustainable income for farmers. The wellness services market research was based on reports by Grand View Research (2023) and the Global Wellness Institute (2024). The Global Wellness Institute report highlighted the significant role of natural therapeutic methods, such as apitherapy, in meeting the demand for health and wellness services. Particular focus was placed on the analysis of innovative technologies, such as the 'therapeutic bee bed in a pyramid' presented by Bienenpyr (n.d.). Technical documentation posted on the company's official website provided detailed information on the effectiveness and commercial application of this technology.

Statistical analysis methods were employed for the analysis, specifically the Student's t-test to assess changes in honey production and regression analysis to forecast the market potential of apitherapy in the wellness industry. All calculations were performed using Microsoft Excel and SPSS Statistics software. The analysis results were presented in graphs and tables, making them clear and accessible for further interpretation. The study was based on official reports and

open sources, including the National Agricultural Statistics Service (2023) and Bienenpyr (n.d.). This ensured the reliability, relevance, and completeness of the findings obtained. All collected data were analysed according to the research objectives, which helped to determine the economic efficiency of apitherapy and the prospects for its integration into the US market.

RESULTS

Overview of beekeeping as an agricultural industry in the United States

Beekeeping is a prominent part of agriculture in the United States, providing honey and other products and playing a key role in pollinating crops (Bienenpyr, n.d.). According to the National Agricultural Statistics Service (2023), honey production in the United States was 125 million pounds in 2022, down 1% from 2021. The number of bee colonies involved in honey production was 2.67 million, also down 1% from the previous year. The average honey yield per colony stayed stable at 47 pounds.

However, honey production increased in 2023. Total production reached 139 million pounds, up 11% from 2022. Although the number of bee colonies decreased by 6% (to 2.51 million), the average honey yield per colony increased by 17% to 55.2 pounds (Grand View Research, 2023). The key honey-producing states are North Dakota, South Dakota, and California. In 2021, these three states saw a 25% decline in production compared to 1991. Overall, honey production in the United States in 2021 was the lowest since 1991 (Gurman, 2022). The development of beekeeping in the United States largely depends on geographical conditions, as climate and the availability of honey plants affect honey production levels. Some states have more favourable conditions for beekeeping and are leaders in honey production. Specifically, North Dakota, South Dakota, and California consistently stay among the largest honey producers in the country (Grand View Research, 2023). Figure 1 presents the main honey-producing states in the United States for 2024.

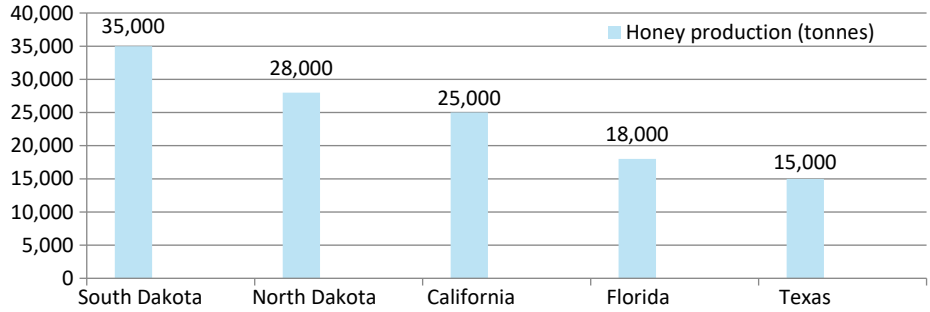

Figure 1. Major honey-producing states in the United States (2024)
Source: developed by the authors of this study based on the Grand View Research (2023)

As Figure 1 shows, North Dakota is the undisputed leader in honey production, accounting for the largest share of the market. This is explained by its favourable climate and abundance of natural pastures, which serve as a source of nectar for bees. South Dakota and California also play a significant role in honey production, while Florida and Texas, despite marked levels of beekeeping, lag behind the top three states. Notably, regional differences in honey production affect pricing and profitability in the industry. For example, in states with warm climates and longer flowering seasons, beekeepers have more opportunities to harvest honey, which can positively influence economic performance. Knowledge of the regional distribution of honey production is significant for entrepreneurs considering investing in the beekeeping business, as it allows them to assess the competitiveness of individual states and the potential for development of this industry in different regions of the United States.

Furthermore, in 2021, demand for honey in the United States reached 618 million pounds

(approximately 280,000 t), equivalent to 1.98 pounds per capita. However, honey imports in the first seven months of 2022 fell by 25%. The key reasons for this decline were stricter measures to combat honey adulteration, the introduction of anti-dumping duties against key exporting countries, and the impact of the COVID-19 pandemic (International honey market..., 2022). Bees play a valuable role in pollinating over 100 crops in the United States, including almonds, fruits, berries, melons, and pumpkins. Insect pollination is considered essential for stable yields of many crops, and its economic value is estimated to be significant (Shvorak & Filiuk, 2021). Pollinators add more than 18 billion USD to the annual value of crops produced in the United States. Individual estimates showed that in 2009, the economic value of honeybee pollination in the United States was approximately 11.68 billion USD. Agricultural research revealed substantial improvements in crop yields when bees were used for pollination. For instance, five of the seven crops under study, such as blueberries, apples, cherries, almonds, and watermelons, produced greater yields when pollinated by bees. The economic effect of pollination was estimated at 1.06 billion USD for apples, 146 million USD for watermelons and 50 million USD for blueberries (Pollinating crops, bees..., 2020).

Considering the growing demand for natural products and environmentally friendly solutions in medicine, the introduction of the latest technologies and methods of apitherapy is a promising area for the development of beekeeping. Apart from the conventional production of honey, propolis, royal jelly, and bee venom, there has been increased interest in recent years in alternative methods of treatment and healing based on bee products. In this context, innovative developments such as the 'therapeutic bee bed in a pyramid' may be promising. Such technologies can be used in the wellness industry, eco-hotels, and alternative medicine centres. They combine conventional apitherapy practices with ecological design concepts, which is in line with current trends in the US health services market.

Beekeeping is a vital part of the US agricultural economy, providing honey and other products, but also playing a key role in pollinating crops. Recent years showed some fluctuations in honey production, but overall demand for bee products continues to be consistently high. The economic value of beekeeping extends beyond the direct production of honey, as pollination contributes to higher yields for many crops. Innovative approaches, including apitherapy, can expand the market for bee products and create new opportunities for entrepreneurs in the industry. Thus, the further development of beekeeping in the United States has considerable economic potential, including its integration into the health and wellness industry.

Economic analysis of the US beekeeping industry

Beekeeping in the United States is a commercially significant industry that combines the production of honey, other bee products, and pollination services for agricultural crops. Honey production continues to be the primary activity of American beekeepers, although they derive a sizeable portion of their income from commercial pollination (Šeráková, 2019). According to the National Agricultural Statistics Service (2023), in 2022, the average price of honey was 2.96 USD/pound, with premium organic honey costing up to 5-7 USD/pound. Apart from honey, a growing demand for products such as propolis, royal jelly, and bee venom is observed, which are used in medicine, cosmetics, and alternative therapies.

Renting bees for pollination is another significant source of income for American beekeepers. In 2023, the average fee for pollinating almonds was 220 USD per hive, the greatest of any crop (Sweeter than honey..., 2020). Other crops, such as apples, blueberries, and watermelons, also require active pollination by bees, which substantially affects yield levels. The contribution of bee pollination to the gross output of US agriculture is estimated at around 18 billion USD. Demand for bee products in the United States stays consistently high, driven by increased interest in natural products and the growing popularity of apitherapy. At the same time, the market structure is changing. Honey imports in 2022 fell by 25% due to tighter controls on counterfeiting, the introduction of anti-dumping duties, and lower production

volumes in major exporting countries (International honey market..., 2023). Still, the segment of niche bee products, such as honey from exotic plants, honey with added functional components, and apitherapeutic honey, is expanding.

The honey market in the United States is experiencing significant price fluctuations, which are caused by both internal production factors and the influence of imports. Due to increased demand for natural honey and the introduction of anti-dumping duties, prices for imported honey have risen in recent years, creating new opportunities for American beekeepers. At the same time, the average cost of local honey stays stable, ensuring relative predictability in beekeepers' incomes. Table 1 below compares the average prices of American and imported honey for 2021-2024.

Table 1. Dynamics of average prices for American and imported honey in the United States (2021-2024)

Year	Average price of American honey (USD/pound)	Average price of imported honey (USD/pound)
2021	6.6-7.8	5.89
2022	6.6-7.8	7.58
2023	6.6-7.8	11.55
2024	6.6-7.8	13.93

Source: developed by the author of this study based on the International honey market as of May 2023 (2023)

As the table 1 shows, the price of American honey has stayed stable at around 6.6-7.8 USD/pound over the last four years. At the same time, prices for imported honey have risen markedly, which can be explained by the introduction of new trade restrictions, US customs policy, and the intensification of the fight against counterfeit products. While imported honey cost 5.89 USD/pound in 2021, its average price in 2023 was already 11.55 USD/pound, more than double the 2021 figure. These changes create favourable conditions for the development of internal honey production in the United States. The decrease in the share of cheap imports contributes to the growth of competitiveness of local beekeepers and an increase in their profits. At the same time, the rise in the cost of imported honey may stimulate the emergence of new producers on the American market, which will require beekeepers to adapt their business strategies to maintain their competitive advantages.

Despite positive economic indicators, beekeeping in the United States faces a series of challenges. The decline in the bee population, which is linked to climate change, pesticide use, and the degradation of natural honey-producing lands, is negatively affecting honey yields and the efficiency of crop pollination. Furthermore, the honey market is affected by alternative sweeteners that compete for consumers. At the same time, rising production costs due to greater equipment, labour, and transport costs are forcing beekeepers to look for new business models.

The prospects for the development of beekeeping in the United States are linked to the expansion of the product range and the introduction of innovative technologies. Interest in natural methods of treatment is opening new opportunities for the development of apitherapy, which is becoming part of the wellness industry. The increased use of honey in pharmacology and cosmetology is creating more sales channels for bee products. The development of eco-hotels and eco-farms contributes to the popularisation of apitherapy as part of a comprehensive approach to health improvement, including new methods such as the 'therapeutic bee bed in a pyramid'.

Research on demand for bee products in the US market

Beekeeping in the United States provides a wide range of products, including honey, propolis, royal jelly, wax, and bee venom. Honey stays the most popular product, used as a natural sweetener and ingredient in cooking. According to the National Agricultural Statistics Service (2023), annual honey production in the United States

exceeds 70 million kg. However, in 2020, production declined by 6%, leading to a 2% increase in the average price to 5 USD/kg. Apart from honey, American consumers are showing growing interest in other bee products. Propolis is known for its antimicrobial properties and is widely used in traditional medicine. Royal jelly is used as a dietary supplement due to its high content of biologically active substances. Beeswax is used in the production of candles, cosmetics, and skin care products, while bee venom is used in apitherapy to treat inflammatory diseases and rheumatic disorders (Gurman, 2022).

The market for bee products in the United States shows stable demand for various types of products, among which honey stays the undisputed leader in terms of consumption. This is caused by its wide use in the food industry, medicine, and cosmetology. However, other bee products, such as propolis, wax, and royal jelly, are also finding their place in the commercial sector, especially in the pharmaceutical and wellness industries. Figure 2 illustrates the demand structure for the key bee products in the United States for 2023, helping to assess which of them have the greatest economic potential.

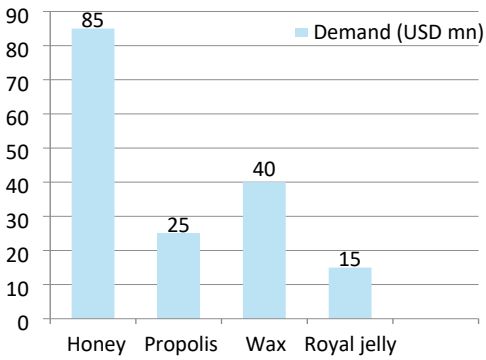

Figure 2. Demand for major bee products in the United States (2024)

Source: developed by the author of this study based on the Grand View Research (2023)

Demand for bee products in the United States stays consistently high, driven by the growing popularity of natural and organic products. Honey is a key product in the market, demonstrating the greatest level of consumption due to its wide application in the food industry, medicine, and cosmetology. Propolis and wax occupy a prominent place in the cosmetic and pharmaceutical industries, which determines their significant commercial potential. At the same time, demand for royal jelly, albeit lower, continues to grow due to interest in biologically active supplements and natural health products. These trends create new opportunities for entrepreneurs working in beekeeping and apitherapy. The expansion of the use of bee products in the wellness industry and alternative medicine opens prospects for the creation of innovative products and services. Thus, the economic potential of the industry remains high, which contributes to the further development of the beekeeping business and its integration into related industries.

Consumer trends in the United States suggest an increased interest in natural and organic products, which is driving demand for bee products. During the COVID-19 pandemic, Americans used honey more actively in their daily diet, which led to an increase in its sales. Consumers viewed honey as a natural remedy for strengthening the immune system, which was particularly noticeable among health-conscious consumers (Gurman, 2022).

Bee products are also being integrated into the health and medical industries. Honey, propolis, royal jelly, and bee venom are used in apitherapy for the prevention and treatment of various diseases, including respiratory and skin disorders. Furthermore, bee products are used in cosmetics and pharmaceuticals due to their antioxidant and antimicrobial properties. Demand for these products is growing due to increasing consumer interest in natural health care and cosmetic products without synthetic additives.

Innovative trends in apitherapy: "Therapeutic bee bed in a pyramid" and their economic feasibility

Recent years have been marked by growing interest in natural medicine and alternative treatments, which markedly increased the popularity of apitherapy. The use of bee products for medical and health purposes has a long history, but modern technologies allow creating new therapeutic methods with greater efficacy and commercial potential. In the context of the global trend towards healthy lifestyles and

environmental awareness, apitherapy is viewed as a promising area of development from both a medical and business perspective.

One example of the latest technologies in apitherapy is the 'therapeutic bee bed in a pyramid' presented by Bienenpyr (n.d.). This technology is based on combining the natural vibrations and bioenergetic properties of beehives with the unique effect of a pyramid structure. According to data provided by the company, this therapy helps normalise blood pressure, improve metabolism, strengthen the immune system, and treat respiratory diseases and nervous disorders.

Innovative apitherapy techniques are already being successfully commercialised in various countries. Specifically, there are numerous api-houses in Germany and Switzerland where patients undergo therapy using bee vibrations and the aromas of beehives. Analogous practices are actively developing in Austria and Canada, where many people turn to alternative medicine to treat stress, insomnia, and chronic diseases. In the United States, the alternative medicine and wellness industry is growing rapidly, creating favourable conditions for the introduction of techniques such as bee therapy.

From an economic standpoint, apitherapy techniques have significant commercial potential. The integration of such technologies into wellness centres, eco-hotels, and sanatorium-resort complexes allows expanding the range of services and attracting new customers. The use of a 'therapeutic bee bed in a pyramid' can become a vital part of recovery and wellness programmes in specialised institutions, contributing to their profitability. Additionally, consumers seeking natural treatments are willing to invest in such services, which increases the profitability of the alternative medicine sector.

The growing popularity of apitherapy services is driving demand for key bee products such as honey, propolis, wax, bee venom, and royal jelly. This is expanding sales markets and creating new premium product segments. According to Grand View Research (2023), the inclusion of honey in wellness service programmes can increase the average margin to 35%-50% compared to conventional retail sales. Propolis and bee venom, thanks to their pharmacological properties, increase in price by 70%-90% when integrated into cosmetic and therapeutic products (Table 2).

Table 2. Comparison of the profitability of bee products by sales channels

Product	Conventional market (USD/kg)	Wellness sector (USD/kg)	Margin growth (%)
Honey	6.6-7.8	10-12	+45-60
Propolis	35	60-70	+70-100
Royal jelly	110	160-180	+45-65
Bee venom	300	500-550	+70-83

Source: developed by the author of this study based on the Grand View Research (2023), Global Wellness Institute (2024), Bienenpyr (n.d.)

Table 2 shows that the sale of bee products in the wellness sector is markedly more profitable than in the conventional market. The largest margin growth is observed in propolis (+70%-100%) and bee venom (+70%-83%), which suggests their high value in the field of health and cosmetology. Honey and royal jelly also show pronounced growth in profitability (+45%-60% and +45%-65%, respectively), but in absolute terms, bee venom (500-550 USD/kg) and royal jelly (160-180 USD/kg) stay the most expensive products. A shift towards the wellness sector could substantially increase the income of bee product producers.

The development of apitherapy positively influences the diversification of beekeepers' income. Apiaries that have introduced apiary huts or bee beds report an increase in annual profits of 30%-40% without a substantial expansion of bee colonies. This model allows transforming an apiary into a multifunctional health and agricultural facility that includes not only production but also services. For example, in Montana, an apiary with 100 hives that also provides apitherapy services earns approximately 30,000-45,000 USD in additional annual income (Grand View Research, 2023). This far exceeds the profits of a conventional apiary operating exclusively

within the food market. Thus, the economic feasibility of apitherapy lies not only in the potential for increasing income in the wellness sector, but also in the comprehensive stimulation of beekeeping development, modernisation of production, and expansion of the niche market for natural products.

The introduction of innovations in apitherapy also contributes to the development of beekeeping as an industry, as the increased demand for bee products stimulates the production of honey, propolis, bee venom, and other apitherapeutic components. Thus, the commercialisation of the latest techniques in this field is a promising area from both a medical and economic standpoint, opening new opportunities for the agricultural and health businesses. The modern development of apitherapy is aimed at creating new therapeutic methods that combine traditional knowledge with innovative approaches. One such solution is the 'therapeutic bee bed in a pyramid', which combines the effects of natural bee therapy with the architectural properties of the pyramidal shape. This technology is based on the principle of using the bioenergy of bees in combination with the design features of the pyramid. The patient lies on a special bed installed directly above a beehive, without direct contact with the insects. The vibrations created by the bees, as well as the volatile components of honey, wax, and propolis, spread throughout the interior of the bed, promoting relaxation, improving blood circulation, and normalising the nervous system. The pyramid structure can act as an energy amplifier for natural biological processes (Bienenpyr, n.d.).

From a market perspective, the introduction of the 'therapeutic bee bed in a pyramid' could become a competitive advantage for the rapidly growing wellness industry in the United States. Over the past decade, alternative medicine and natural healing methods have gained widespread recognition among American consumers, as evidenced by the growing demand for natural therapeutic techniques. Owners of wellness centres, eco-resorts, and medical sanatoriums, who are constantly looking for new opportunities to expand their range of services, are particularly interested in unconventional methods.

The integration of this technology into apitherapy practice in the United States has several promising areas. Firstly, it can be implemented in specialised wellness centres and apitherapy clinics that use natural healing methods. Secondly, the concept of a 'therapeutic bee bed in a pyramid' can be adapted for ecotourism and rural wellness holidays, which are especially popular among consumers seeking harmony with nature. Furthermore, individual wellness programmes could be created to include this technology as part of a comprehensive approach to the treatment and prevention of diseases of the nervous and respiratory systems and the overall strengthening of the immune system.

From an economic standpoint, the introduction of the 'therapeutic bee bed in a pyramid' could become a source of new income for apiary owners and entrepreneurs in the wellness business. The demand for innovative relaxation and therapy methods in the United States is showing steady growth, making such technologies attractive to investors and businesspeople. Specifically, the use of this method in the wellness industry allows creating package wellness services that include comprehensive treatment using natural methods.

Since the American alternative medicine market is one of the largest in the world, the further development of apitherapy in the United States may include the introduction of the 'therapeutic bee bed in a pyramid' as a new standard for wellness programmes. The successful commercialisation of this technology in European countries such as Germany and Austria demonstrate its potential for international expansion. With growing interest in natural treatments, this technology could become a valuable element in the development of apitherapy and contribute to expanding economic opportunities in the beekeeping industry.

Business aspects of the "therapeutic bee bed in a pyramid" in the United States

The alternative medicine and wellness industry in the United States is showing steady growth, creating favourable conditions to introduce innovative apitherapy techniques. The "therapeutic bee bed in a pyramid" could become a new business tool for expanding the range of

wellness services in various sectors. One of the most promising areas is the wellness industry, which includes spa complexes, fitness centres, medical resorts, and health resorts. In the United States, the wellness services market is estimated at over 1.5 trillion USD and is growing by 5%-10% annually (Global Wellness Institute, 2024). Considering the popularity of speleotherapy, cryotherapy, sensory deprivation, bee bed technology may find its niche as a new method of deep relaxation and nervous system restoration.

Another area is eco-tourism and eco-hotels, which focus on natural health methods. Hotels and sanatoriums offering organic food, microclimate therapy, and energy-efficient solutions are actively introducing natural methods of treatment and relaxation. The integration of bee beds as part of specialised wellness programmes can increase the competitiveness of such establishments and attract a new category of customers. The third promising segment is alternative medicine centres working in the field of prevention and rehabilitation. The popularity of non-drug treatments is growing in the United States, and apitherapy is already in steady demand among patients with chronic inflammatory processes, nervous system disorders, and respiratory problems. The introduction of the 'therapeutic bee bed in a pyramid' in such centres can help expand the range of services and increase the average customer spend.

From an investment standpoint, the commercialisation of this technology looks promising. The average cost of an apitherapy session in the United States ranges from 50 USD to 200 USD, depending on the level of the facility and the duration of the procedure. Assuming that an average wellness centre conducts 20 sessions per day at an average cost of 120 USD per procedure, this yields a potential daily income of 2,400 USD, and per month (working 25 days) – 60,000 USD. The costs of implementing the technology include the purchase of equipment, setting up the premises, and marketing. The approximate cost of installing a single 'therapeutic bee bed in a pyramid' can range within 10,000-30,000 USD, depending on the configuration and location. Thus, the return on investment can be 6-12 months, which is quite fast for the wellness business.

Furthermore, this technology can be monetised through franchising. Owners of successful wellness centres can implement this concept as a separate business project, offering franchises to operators of wellness centres or tourist complexes. An analogous model is already working in Europe, where wellness techniques based on bee products are used in medical resorts and eco-residences. Thus, the 'therapeutic bee bed in a pyramid' has high commercialisation potential in the United States due to its combination of an innovative approach, stable growth in the wellness services market, and the possibility of a quick return on investment. This technology could become a new standard in alternative medicine, expanding business opportunities and creating additional economic incentives for the development of apitherapy and beekeeping in general.

Beekeeping and apitherapy are vital components of the US agricultural industry with a promising growth potential. Demand for bee products continues to be consistently high due to growing interest in natural foods and alternative medicine. Apart from the conventional production of honey, propolis, wax, and other bee products, the sector is expanding into the commercialisation of apitherapy, opening new opportunities for agribusiness. The introduction of innovative apitherapy methods allows expanding the scope of application of bee products, integrating them into the wellness industry, eco-tourism, and alternative medicine. Growing consumer interest in natural treatments is stimulating investment in new therapeutic solutions, which may positively influence the economic attractiveness of beekeeping as an industry. Considering the size of the alternative medicine and wellness services market in the United States, which is estimated at over 1.5 trillion USD and continues to grow, apitherapy can scale up and integrate into medical and tourism business models.

One example of a successful innovative development in this field is the 'therapeutic bee bed in a pyramid', which combines traditional apitherapy methods with elements of energy architecture. Its commercial potential lies in its potential for implementation in wellness centres, eco-hotels, and alternative medical facilities. The demand for new health improvement

methods among American consumers creates favourable conditions for the commercialisation of this technology. To fully cover the economic aspect of introducing the innovative technology of the 'therapeutic bee bed in a pyramid', it is advisable to analyse not only the potential income but also the main costs associated with its implementation. Table 3 presents approximate financial indicators for the implementation of this technology in an average wellness centre.

Table 3. Financial analysis of the implementation of the "bee bed" technology in the wellness business

Indicator	Value
Average cost per session	120 USD
Number of sessions per day	20
Daily income	2,400 USD
Monthly income (25 working days)	60,000 USD
Approximate cost of equipment	10,000-30,000 USD
Expenses for maintaining bee colonies (per year)	2,000-4,000 USD
Personnel expenses (per month)	3,000-4,500 USD
Energy costs, rent, other (per month)	1,500-2,500 USD
Total monthly expenses	4,500-7,000 USD
Net monthly profit	53,000-55,500 USD
Payback period, considering costs	6-12 months

Source: compiled by the author of this study based on marked data and assessments from Bienenpyr (n.d.)

As Table 3 demonstrates, with moderate operating costs and a stable customer flow, the payback period is 6-12 months. Net profit can exceed 50,000 USD per month, which indicates the high profitability of the project. Another advantage is the possibility of upscaling – installing several beds, creating service packages, or combining with other wellness programmes. Thus, investments in the introduction of bee beds have a high return on investment and contribute to the development of both apitherapy and related industries, specifically beekeeping.

Thus, the development of beekeeping and apitherapy in the United States is not only of agricultural but also of economic significance. The introduction of innovative techniques allows expanding the range of uses for bee products, creating new business models and opportunities for entrepreneurs. The commercialisation of apitherapy through the introduction of technologies such as the "therapeutic bee bed in a pyramid" can contribute to the economic growth of the industry and strengthen its position in the alternative medicine and wellness industry in the United States.

DISCUSSION

The obtained results confirmed the significance of institutional support in the development of beekeeping, which was consistent with the findings of P. Šeráková (2019), who studied successful examples in the Czech Republic and Switzerland. However, in the United States, the role of government support was less significant, and commercial pollination became the key factor. E. Oyedokun & B. William (2025) analysed the role of honey in ensuring sustainable livelihoods in Niger, where beekeeping has become a prominent factor in supporting the local economy and improving social conditions. This was consistent with the findings of the present study, which confirmed the value of beekeeping development as a factor of economic stability that stimulates not only honey production but also the creation of new jobs and opportunities for sustainable development of rural areas. A. Kuś (2025) emphasised the significance of innovative management in Polish apiaries.

In the United States, this approach has been partially implemented through the integration of beekeeping into large agro-industrial complexes, which differs from the predominantly farming nature of the industry in the Balkan region. The development of apitherapy and apitourism, studied by B.P. Koç & G. Özgürel (2023), opens new opportunities for integrating bee products into wellness programmes. The results of the study confirmed the promise of technologies

such as the 'therapeutic bee bed in a pyramid' in the United States. J. Mota-Gutierrez *et al.* (2024) showed that sustainable beekeeping stimulates demand among environmentally conscious consumers in Belgium. An analogous trend was observed in the United States, where an emphasis on environmental friendliness contributed to the popularity of beekeeping products.

The results of a study on the effects of sustainable beekeeping on agribusiness confirmed the conclusions of F. Lazzari (2023), who proposed guidelines for sustainable beekeeping that improve environmental quality. As the results of empirical analysis showed, the greening of technologies in beekeeping correlated positively with the economic efficiency of farms and contributed to the preservation of agrobiodiversity. The study emphasised the value of introducing sustainable practices, particularly the avoidance of excessive pesticide use, the conservation of natural land, the integration of nature-friendly approaches to apiary location, and the development of plant-oriented systems. The findings confirmed that these factors contribute to increased honey yields, reduced bee colony losses, and stabilisation of the industry's economic profitability.

S. Akyürek (2022) focused on the potential of apitourism to promote beekeeping through interactive exhibitions, including the creation of specialised museums, demonstration apiaries, and educational centres. This approach helps to create a positive image of beekeeping among a wide audience, raise environmental awareness, and stimulate demand for beekeeping products. The present findings were partly consistent with this approach, especially in the context of expanding the functional load of apiaries, particularly through the integration of apitherapy, demonstration procedures, and tourist services. In the United States, such integration proved to be an effective model for diversifying income, combining conventional honey production with health and tourism initiatives. According to the analysis, the creation of recreational infrastructure elements such as apiary houses based on apiaries not only provides added income but also enhances the sustainability of rural areas.

M. Vercelli *et al.* (2023) investigated the trade-off between sustainable beekeeping and profitability in the implementation of biotechnical methods of controlling the Varroa destructor mite. The researchers emphasised that although such methods require extensive initial investment and a greater level of professional training for beekeepers, their use reduces the toxic load on the ecosystem, preserves the health of bee colonies, and increases the long-term productivity of apiaries. In the United States, this practice is already gaining support, especially among organic honey producers, but high implementation costs continue to be a deterrent for small farms.

The study results confirmed that the development of the beekeeping market is a promising area for stabilising the agricultural business, which coincided with the conclusions of A. Chmil (2023). The researcher analysed the role of beekeeping in the context of global challenges, particularly in Ukraine, where the focus was on optimising the production and marketing of honey and other bee products. B. Dukhnytskyi & V. Dukhnytskyi (2020) analysed Ukraine's role in the global honey market. The authors emphasised the export orientation of the industry and the need to diversify beekeeping products, which is consistent with the idea of introducing innovative apitherapy technologies. Their findings confirm that the development of beekeeping has significant economic potential and can be effectively combined with the wellness sector, as studied in the example of the United States. Analogous trends were observed in the United States, although the market size and level of technological development differed significantly. V.R. Monastyrskyi *et al.* (2023) pointed out the significance of developing apitourism as an innovative area that combines beekeeping and the tourism industry. In the United States, analogous observations revealed that integrating beekeeping into tourism through apitherapy and excursion programmes can substantially diversify farm income. The difference was that the American market focused more on health services, such as 'therapeutic bee bed in a pyramid'.

Researchers A.A. Cucu *et al.* (2022) focused on the bioactive properties of *Calluna vulgaris*, emphasising its value for apitherapy. The findings of this study confirmed that apitherapy has promising potential for expanding the market for bee products, including the development of new products based on plant components. This is consistent with the growing demand for

natural health products in the United States. G.O. Ominde (2014) focused on the added value of beekeeping products for improving the welfare of farmers in Kenya. The findings of this study coincided with the findings in the current study, which showed that the introduction of innovations in the production of bee products (such as apitherapy technologies) can markedly increase beekeepers' incomes and contribute to the diversification of agribusiness. B. Bekić & M. Jovanović (2015) investigated the role of beekeeping in the sustainable development of the Danube region. Their study emphasised that the integration of beekeeping into local economic systems contributes to job creation and the conservation of natural resources. Analogous trends were observed in the United States, where the use of bee products for pollination of agricultural crops and the introduction of sustainable practices contributed to the profitability of agribusinesses.

R. Prodanović *et al.* (2024) emphasised the value of beekeeping for the sustainable development of rural areas, particularly through the creation of additional sources of income and the promotion of social stability. These findings were confirmed in the present study, which found that commercial pollination in the United States not only improves crop yields but also supports the development of rural regions. V. Patel *et al.* (2021) emphasised the value of bees for achieving sustainable development goals, particularly through their contribution to food security. The results of the present study confirmed that pollination by honeybees is a key factor for stable food crop production in the United States.

J. Hinton (2021) noted that the stability of honey prices in the United States is a result of the established market infrastructure, an efficiently functioning logistics system, cooperative associations of beekeepers, and the existence of a developed quality certification system that guarantees consumer confidence in locally sourced products. The findings obtained in the present study confirmed these observations, demonstrating the stability of average prices for American honey within 6.6-7.8 USD/pound over the past few years. At the same time, as evidenced by the analysis of statistical data, prices for imported honey showed rapid growth. While in 2021 the average price was 2.67 USD/kg (5.89 USD/pound), by 2023 it reached 5.24 USD/kg (11.55 USD/pound), more than double the previous value. This price increase occurred against the backdrop of tighter quality control, the introduction of anti-dumping duties against certain exporting countries, and changes in foreign trade regulation policy. According to M. Bie *et al.* (2025), such measures are a manifestation of growing protectionism in the US agri-food sector and are in line with the global trend of protecting internal markets from low-quality or subsidised imports. The researchers emphasised that trade barriers, including tariff and non-tariff restrictions, became a substantial factor in the rise in prices for imported agricultural products. In this context, the situation on the US honey market is indicative: on the one hand, tighter import controls helped to increase the competitiveness of domestic producers, but on the other hand, they drove up consumer prices.

M.S. Younis & E.A. Ali (2024) pointed to the significance of sustainable practices as a key factor in improving the profitability of beekeeping in the face of modern challenges in agricultural production. The researchers emphasised that the introduction of environmentally friendly approaches, such as reducing chemical pollution, optimising seasonal movement of apiaries, and preserving honey-producing flora, positively influences both the productivity of bee colonies and the quality of the final product. In the United States, these approaches are being implemented through a transition to organic beekeeping, zoning of beekeeping activities, introduction of biological control of diseases and pests, and enhanced cooperation between beekeepers, agricultural producers, and regulatory bodies.

The development of apitherapy and apitourism, studied by S.B. Wibowo *et al.* (2024), also found confirmation in the United States, where interest in these areas is growing. The integration of apitherapy into health programmes opens new opportunities for the commercialisation of bee products, which is consistent with the findings of E. Clemente Alves & C. Rimoli (2022) on innovative approaches in small businesses in the beekeeping sector. These findings also point to the significance of expanding markets and introducing innovative technologies to support the stability and development of beekeeping.

The obtained findings confirmed that beekeeping has prominent potential to stimulate

economic development, social stability, and preserve ecological balance. In the United States, thanks to developed infrastructure and sales markets, barriers to the development of beekeeping were significantly lower, which allowed the industry's potential to be effectively utilised for economic development. The integration of innovative technologies, such as the introduction of sustainable practices, increased the efficiency of the industry. The study also confirmed the value of introducing apitherapy and apitourism to diversify beekeepers' incomes and develop rural areas. However, despite the positive outcomes, some regions faced economic challenges caused by the prohibiting costs of introducing innovative technologies. Overall, the sustainable development of beekeeping contributed to improving the economic efficiency of agribusiness and preserving biodiversity.

CONCLUSIONS

The study comprehensively analysed the economic prospects for the development of beekeeping and apitherapy in the United States, which allowed identifying key trends, determining the commercialisation potential of bee products, and assessing the profitability of introducing innovative methods in the industry. The study found that beekeeping plays a major role in the US agro-industrial complex, providing not only honey production but also pollination services, the value of which to the agricultural sector is estimated at over 18 billion USD annually. Honey production in 2023 increased by 11% compared to 2022, reaching 139 million pounds, despite a 6% reduction in the number of bee colonies. The key production regions continue to be North Dakota, South Dakota, and California, confirming the stability of the regional distribution of the beekeeping industry. Market analysis revealed that demand for honey and other bee products stays consistently high. A gradual 25% reduction in honey imports was observed, driven by tighter product quality controls, creating favourable conditions for the expansion of internal production. At the same time, the commercial potential of niche bee products such as propolis, wax, and royal jelly, which are in high demand in the pharmaceutical and cosmetics sectors, is growing.

Particular attention was paid to the prospects for the development of apitherapy. The study found that the market for alternative medicine and wellness services in the United States is estimated at over 1.5 trillion USD and is showing steady growth. The demand for natural therapeutic methods is driving the expansion of the apitherapy segment, opening opportunities for the integration of bee products into the field of health and non-drug treatment. The study also confirmed the high commercial potential of introducing the 'therapeutic bee bed in a pyramid' as an innovative apitherapy method. The analysis showed that its integration into wellness centres, eco-hotels, and medical institutions can help expand the range of services and attract new customers. Profitability estimates suggest that the average payback period for the technology is 6 to 12 months, making it economically viable for businesses.

A limitation of this study was the lack of long-term data on the economic effects of introducing the 'therapeutic bee bed in a pyramid', which requires further analysis in the future. At the same time, further research could focus on expanding the analysis of the international market for bee products, studying the effects of climate change on honey production, and the long-term economic efficiency of the latest apitherapy methods. The findings confirmed that the development of beekeeping and apitherapy has considerable economic potential and opens new opportunities for the commercialisation of natural treatment methods in the United States.

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Анатолій Ольшанський
Магістр
Донецький державний університет внутрішніх справ
25000, вул. Велика Перспективна, 1, м. Кропивницький, Україна
https://orcid.org/0009-0001-5270-4937

Бізнес ефективність використання «бджолиного лікувального ліжка в піраміді» у сфері оздоровлення населення Америки

Анотація. Метою дослідження було проаналізувати економічні перспективи розвитку бджільництва в Сполучених Штатах Америки, зокрема вивчити можливості інтеграції апітерапії в аграрний сектор та wellness-індустрію. Основна увага приділялася впливу бджільництва на економіку, аналізу попиту на продукти бджільництва та можливостям комерціалізації інноваційних методів апітерапії. Методологія включала аналіз статистичних даних, оцінку динаміки виробництва меду, вивчення ринкових тенденцій та оцінку економічної ефективності нових методів лікування на основі бджолопродуктів. У ході дослідження встановлено, що виробництво меду в Сполучених Штатах Америки у 2023 році становило 139 мільйонів фунтів, що на 11 % більше, ніж у 2022 році, попри зменшення кількості бджолосімей на 6 %. Водночас середній медозбір на одну сім'ю зріс на 17 %. Основними штатами-виробниками залишаються Північна Дакота, Південна Дакота та Каліфорнія. Попит на мед та інші продукти бджільництва залишається стабільно високим, при цьому імпорт меду скоротився на 25 % через посилений контроль за якістю продукції. Окремо було оцінено внесок бджолозапилення у сільське господарство, що оцінюється у понад 18 мільярдів доларів щорічно. Особливу увагу було приділено перспективам апітерапії. Аналіз показав, що ринок альтернативної медицини та wellness-послуг у Сполучених Штатах Америки оцінюється у понад 1,5 трильйона доларів і демонструє стабільне зростання. Інноваційні технології, зокрема «бджолине лікувальне ліжко в піраміді», мають високий комерційний потенціал завдяки попиту на натуральні терапевтичні методи. Оцінено, що впровадження цієї технології у wellness-центрах та еко-готелях може окупитися в межах 6-12 місяців. Практична значимість дослідження полягала у тому, що отримані результати можуть бути використані підприємцями, інвесторами та фахівцями у сфері бджільництва, альтернативної медицини та wellness-бізнесу для оцінки рентабельності розширення бізнес-моделей на основі апітерапевтичних технологій

Ключові слова: мед; оздоровлення; wellness-індустрія; медицина; біоекономіка

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03041, вул. Героїв Оборони, 13, м. Київ, Україна
Tel.: +38(044)-258-42-63
E-mail: info@economicscience.com.ua
https://economicscience.com.ua/uk

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Editors office address:

National University of Life and Environmental Science of Ukraine
03041, 13 Heroiv Oborony Str., Kyiv, Ukraine
Тел.: +38(044)-258-42-63
E-mail: info@economicscience.com.ua
https://economicscience.com.ua/en