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The impact of Ukrainian imports on the food security of its trade partners

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► **Abstract.** The relevance of the problem under study is that changes in foreign markets can significantly affect the food sector of other countries, and global food security, measured by a set of indicators, including the Global Hunger Index, is one of the main threats to international economic stability. The research aimed to assess the relationship between the food security of China, Bangladesh, Sri Lanka, Pakistan, Vietnam, Indonesia, and India and the dynamics of their imports of agricultural and food products from Ukraine. The study used a range of methods, including an analysis of the dynamics of the Global Hunger Index of Ukraine's largest importers, and structural and regression analysis of agricultural imports from Ukraine. The results revealed a positive impact of Ukraine's food imports on the food security of several countries. Specifically, the study found that imports of vegetables from Ukraine have a positive impact on China's food security, while Ukrainian milk, dairy products, poultry eggs, natural honey, oilseeds, and oilseed fruits help to ensure food security in Indonesia. Grain imports from Ukraine also have a positive impact on Pakistan's food security. However, the study did not confirm a statistically significant correlation between the dynamics of the Global Hunger Index and food imports from Ukraine to Bangladesh, India, Sri Lanka, Vietnam, and Vietnam in the period from 2011 to 2023. The study's practical significance is determined by understanding the impact of Ukrainian imports on trading

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partners' food security, as well as the need to develop strategies to diversify supplies and stimulate domestic production in order to guarantee the resilience and sustainability of these countries' food sectors

► **Keywords:** international trade; sustainable; Global Hunger Index; regression analysis; international markets

► Introduction

At the beginning of 2023, the world faced several acute challenges that seriously affected food security in different regions. Geopolitical conflicts and the war in Ukraine have become one of the main reasons for the growing instability in global food markets. The escalation of geopolitical conflicts has led to restrictions on the movement of goods and resources, as well as to a decline in agricultural production in some countries. In particular, the stoppage of grain supplies from Ukraine to world markets led to higher prices for bread products, which exacerbated the global food crisis (Zaliznyuk, 2022).

As V. Myronchuk *et al.* (2022) state that after the start of Russia's full-scale armed invasion of Ukraine in 2022, supply chains are disrupted and the global economic recovery from the pandemic is slowing down significantly. The author notes that global agricultural markets are currently under pressure as demand for food is constantly growing and supply is becoming increasingly limited. L. Tsymbal & T. Chernytska (2022) state that a sharp rise in food prices leads to a deterioration in global food security. The author notes the importance of establishing Ukraine's role in shaping global food security, studying the impact of the war in Ukraine on the international food market, and identifying ways to mitigate the negative effects of this impact for an extended period. The relationship between the economy and war is explored in I. Sas *et al.* (2022) confirm that the armed conflict has become an integral part of modern Ukraine, significantly changing all spheres of public life. This has led to a new understanding of the nature of modern wars and their impact on the economy, both locally and globally. The key factors for successful post-war recovery will be rational decision-making, pragmatic goals, and a focus on improving the overall security of the country (including economic, social and military security) (Leshchenko & Leshchenko, 2023). According to the author, only by taking these determinants into account can sustainable development and prosperity be ensured after a period of armed conflict.

V. Boiko & L. Boiko (2022) note the importance of food security for the state, namely the importance of adequate food supply to the population, which contributes to the stability of society, reduces the risks of social tensions, and ensures sustainable development. According to the authors, when people have access to sufficient food, the risk of mass protests, unrest or social conflicts related to hunger or lack of food availability is reduced. Finally, O. Shevchenko (2022) concluded that food security is one of the key components of Ukraine's economic security. Ensuring food security includes the creation of strategic documents, laws and programmes aimed at developing the agricultural sector to ensure access to food for all segments of the population. In addition, the food security policy should consider international aspects, cooperation with other countries and participation in international organisations, which contributes to ensuring stable food security at the global level (Trusova *et*

al., 2021). The significant impact of geopolitical conflicts, particularly the war in Ukraine, on global food security has been highlighted. This research aimed to investigate the relationship between the volume of Ukrainian food imports, their impact on the food security of Ukraine's partner countries that trade with it and identify possible consequences for the food security of these countries.

► Materials and methods

The methodology employed in this research is based on a comprehensive approach that includes both quantitative and qualitative methods. To answer the question of how the supply of agricultural and food products from Ukraine affects the food security of its largest trade partners, authors will use the functional dependence of the level of their national food security on the volume of their imports of agricultural and food commodities (1):

$$Y_i = f(\text{volimp}1; \text{volimp}2; \text{volimp}3; \text{volimp}N), \quad (1)$$

where Y_i is the Global Hunger Index for the country i that imports agricultural and food products from Ukraine; $\text{volimp}1 \dots \text{volimp}N$ is the volume of imports of agricultural and food commodities commodity groups by the country i from Ukraine.

The commodity groups used in this research are the following commodity groups of the Harmonised Commodity Description and Coding System (HS):

1. HS04 Dairy produce; birds' eggs; natural honey; edible products of animal origin...
2. HS07 Edible vegetables and certain roots and tubers.
3. HS10 Cereals.
4. HS12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds, and fruit; industrial or medicinal...
5. HS15 Animal or vegetable fats and oils and their cleavage products...

To test this hypothesis, authors build a linear regression model that is described by the following equation:

$$Y = \beta_0 + \beta_1 \cdot x_1 + \dots + \beta_k \cdot x_k + u, \quad (2)$$

where Y is the dependent explanatory variable, $(x_1, x_2, \dots, x_k)$ are the independent explanatory variables, and u is a random error whose distribution is generally determined by the independent variables but whose mathematical expectation equals zero.

The data used in this model (2) are measured in different units of scale, because of this they must be standardised using the natural logarithm. Thus, the equation for regression analysis takes the following form:

$$\ln Y = \beta_0 + \beta_1 \ln(\text{volimp}1) + \beta_2 \ln(\text{volimp}2) + \beta_3 \ln(\text{volimp}3) + \beta_n \ln(\text{volimp}N) + u. \quad (3)$$

To carry out a regression analysis and develop a model of food security dependence of major importers of Ukrainian agricultural and food commodities, authors will use data of changes of the Global Hunger Index in the

countries in question and data on exports of agricultural and food commodities provided by the Official website of the State Statistics Service of Ukraine (n.d.) for the period of 2010-2023. Key documents such as the Global Hunger Index (2023) reports and Official website of the State Statistics Service of Ukraine (n.d.) were utilised to track food security trends in Ukraine's major trade partners, including China, Bangladesh, and Pakistan. Additionally, data from Export of Agriproducts (n.d.) were analysed to assess changes in agricultural exports following the Russian invasion in 2022. The quantitative aspect of the research involved conducting regression analysis to model the relationship between Ukrainian food exports and the Global Hunger Index in the selected countries. The dependent variable in the regression models was the Global Hunger Index, while independent variables included trade volumes of specific agricultural commodities, such as dairy produce, birds' eggs; natural honey (HS04), edible vegetables and certain roots and tubers (HS07), cereals (HS10), oil seeds and oleaginous fruits; miscellaneous grains, seeds, and fruit (HS12), animal or vegetable fats and oils (HS15).

To identify the role of Ukraine in improving the state of food security of its main trading partners, authors will conduct a study of the dependence of the dynamics of the Global Hunger Index in these countries on the amount of food that is imported from Ukraine. In this research, authors selected countries that meet the following conditions: the Global Hunger Index of the country is greater than 5 points, which indicates the presence of threats to food security; the country is dependent on the imports of food products; the country is a major importer of agricultural and food commodities from Ukraine. The countries that met those criteria are Bangladesh, China, India, Indonesia, Pakistan, Sri-Lanka, Vietnam. The regression analysis is going to be carried out with the Multiple Regression module of the Statistica software 7.0. Thus, the proposed study of the impact of Ukraine on the food security of its main trade partners utilises the following methodological

approaches and methods: (1) analysis of the dynamics of the Global Hunger Index of the largest importers of agricultural and food commodities from Ukraine for identification of countries with high threats to food security; (2) structural analysis of imports of Ukrainian agricultural commodities by countries with high Global Hunger Index, identification of the largest commodity groups; (3) regression analysis to demonstrate the dependency of the dynamics of the Global Hunger Index of the identified countries in question on changes in the structure of their imports of agricultural and food commodities from Ukraine.

► Results

Ukraine is a world leader in the supply of sunflower, vegetables, wheat, barley, sugar beets, fruits, tobacco, legumes, and corn to international markets. Over 55% of Ukraine's territory is arable, and agriculture provides work for 14% of Ukraine's population. Agricultural commodities are the most important item of export of Ukraine (27.8 billion USD in 2021, 41% of the country's total exports of 68 billion USD) (Official website of the State Statistics Service of Ukraine, n.d.). Full-scale Russia's invasion of the Ukrainian territory in February 2022 has left a massive impact on global food security disrupting the supply chains, increasing prices on international food markets, and creating a risk of famine on global scale. According to the Ukrainian government, after the start of the invasion, the global market lost more than 20 million tons of projected Ukrainian food exports, and overall Ukraine has supplied three times less agricultural and food commodities than was planned for 2022. After the introduction of martial law, the Ukrainian government limited the export of basic food products (wheat, oats, millet, buckwheat groats, sugar, meat, and meat offal). This have caused an immediate response from United Nations experts sounding the alarm of the danger of a hunger crisis in various countries. The main destination of Ukraine's agricultural exports is Asia, particularly, China, Indonesia, Vietnam, Pakistan, Bangladesh, India and Sri-Lanka (Fig. 1).

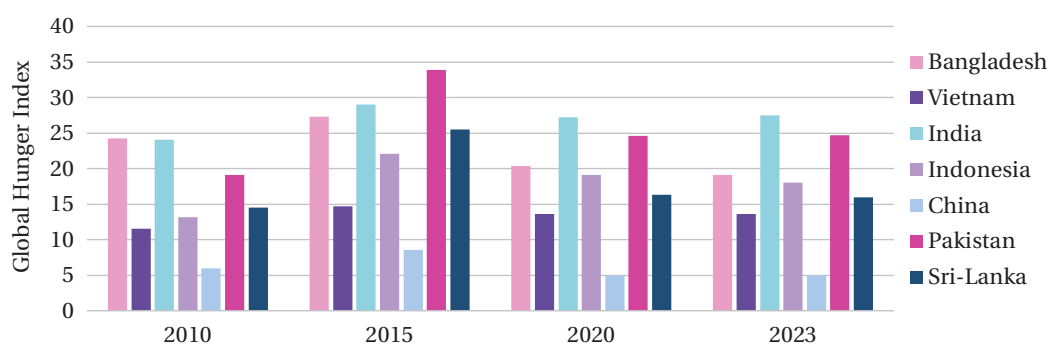


Figure 1. Dynamics of the Global Hunger Index of Ukraine's major trade partners in Asia

Source: Global Hunger Index (n.d.)

In 2010-2023, only China made a significant improvement in its food security decreasing the value of the Global Hunger Index from 6 to 5 points. A slight improvement of this indicator was also observed in Bangladesh (a decrease from 24.2 points in 2010 to 19.1 points in 2023). The food security of other researched countries has significantly worsened, as evidenced by an increase in the

value of their Global Hunger Index in the same period. However, the Russian-Ukrainian war, which began on 24 February 2022, has hurt imports of Ukrainian products to Asia. On the one hand, the war has led to a decline in production in Ukraine and an increase in prices for Ukrainian goods. On the other hand, the war has also led to a reorientation of Ukrainian exports to other markets,

in particular Europe and the United States. As a result, the volume of imports of Ukrainian products to Asia in 2022 decreased by more than 50% compared to 2021. This harmed the economies of importing countries, which lost access to cheap Ukrainian goods. The analysis of the dynamics of agricultural and food exports from Ukraine to China reveals the major increase in the volumes of trade. The statistical data presented in Table 1 suggest that the

improvement in the food security of China and the following decrease of the Global Hunger Index was achieved by the increase of agricultural (primarily cereals) imports from Ukraine was relevant up to 2021. To test this hypothesis, authors conducted a regression analysis and design a model of the linear dependence of the Global Hunger Index on changes in China's imports of food resources from Ukraine.

Table 1. Input data for a regression analysis of the impact of food exports from Ukraine on the change of the Global Hunger Index of China

Year	Dependent variable		Independent variable			
	Global Hunger Index <i>HGI_Ch</i>	HS04 <i>X_{1_Ch}</i>	Value of Imports, thousands of USD			
			HS07 <i>X_{2_Ch}</i>	HS10 <i>X_{3_Ch}</i>	HS12 <i>X_{4_Ch}</i>	HS15 <i>X_{5_Ch}</i>
2011	5.5	5,330.4	2	1.3	798	94,621.8
2012	5.1	4,490.5	2.3	0.2	1208.5	71,707.6
2013	5.5	3,448.2	4.3	26,092.3	291.8	436,590.5
2014	5.4	2,504.5	8.1	368,821.2	302.3	363,558.8
2015	8.6	1,613.9	0.9	676,940.7	681.7	533,208.2
2016	7.7	2,121.7	3.3	464,139.9	3,761.7	527,220.6
2017	7.5	11,760.2	8.6	447,333.1	6,009.4	511,112.6
2018	7.6	16,730.7	30.2	552,235.5	202.3	426,064.4
2019	6.5	26,796.3	99.9	858,653.3	12,521	741,273.8
2020	5	17,478.2	582.6	1,854,823.8	25,490.7	1,100,623.8
2021	5	8,321.8	533.7	2,552,513.9	24,032.8	987,852.4
2022	7	4,211.3	246.1	1,263,340.3	11,998.7	455,279.3
2023	5	5,468.6	181.4	1,131,428.8	12,349.1	624,268.6

Source: Global Hunger Index (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Conducted regression analysis reveals a strong connection between the Global Hunger Index in China and the change in the volumes of food imports from Ukraine in 2011-2023. This is demonstrated by the high correlation coefficient. ($R=0.897$). The growing volumes of vegetable imports from Ukraine had a positive impact on China's food security: a 1% increase in the volumes of imports of HS07 "Edible vegetables" commodity group contributed to a decrease in the Global Hunger Index by 0.125%:

$$HGI_{Ch} = 0.522 + 1.146 * X_{1Ch} - 0.125 * X_{2Ch} + 0.033 * X_{3Ch}. \quad (4)$$

At the same time, a direct relationship between China's Global Hunger Index and the imports of HS04 "Dairy produce..." was observed. When the independent variable grew by 1%, the dependent variable also increased by 0.145%. This negative impact of the imports of dairy products from Ukraine on the food security of China can be explained by the fact that in most Chinese provinces dairy products do not belong to the traditional ration of local population. A negative impact of imports of HS10 "Cereals" on China's food security was also revealed: a 1% growth in the independent variable resulted in a 0.033% increase in the dependent variable. This can be explained by the fact that grain imported from Ukraine is used in China as livestock feed for the further production of meat products, which not every resident can afford to buy in the sufficient quantity. The coefficient of determination indicates that the Global Hunger Index in China in 2011-2023 was 80.6% dependent on changes in the volume of imports

of HS04, and of HS10 "Cereals", and 19.4% dependent on changes in other factors. The level of statistical error does not exceed 5%, which confirms the statistical significance of the regression analysis. The calculated value of Fisher's test is 9.711 and exceeds its tabular value (3.7), so authors can assume the relationship between the dependent and independent variables to be significant.

Therefore, the improvement of China's food security in 2011-2023 was due to the increase in the volume of imports of vegetables from Ukraine, and the increase of the imports of Ukrainian dairy products and cereals negatively affected the value of the Global Hunger Index, lowering China's food security. At the same time, the impact of imports of HS15 "Animal or vegetable fats and oils commodity group..." from Ukraine on the dynamics of China's Global Hunger Index turned out to be statistically insignificant. According to the United Nations Food and Agriculture Organization, Ukraine's food exports in 2022 decreased by 60% compared to 2021. Grain exports, in particular wheat, corn, and barley, decreased the most. Exports of these crops decreased by 58%, 51%, and 20%, respectively. Exports of oilseeds, in particular sunflower oil, also decreased by 41%. A similar regressive analysis was conducted for Indonesia, Pakistan, Bangladesh, India, and Sri-Lanka. In 2017-2021 the Global Hunger Index of Indonesia decreased from 22 to 18 points, leading to the improvement in food security. During this period, there was a significant increase in the import of vegetables, cereals, fats, and oils of animal or vegetable origin from Ukraine (Table 2).

Table 2. Input data for a regression analysis of the impact of food exports from Ukraine on the change of the Global Hunger Index of Indonesia

Year	Dependent variable		Independent variable			
	Global Hunger Index		Value of Imports, thousands of USD			
	HGI_Ch	HS04 X_{1_Ch}	HS07 X_{2_Ch}	HS10 X_{3_Ch}	HS12 X_{4_Ch}	HS15 X_{5_Ch}
2011	12.2	2,288.1	145.7	744.5	361.4	0
2012	12	2,490.3	26.6	9,044.2	1,902.5	0
2013	10.1	3,655.2	80.1	64,465.1	2,555.5	292.4
2014	10.3	6,081.9	72.4	68,928.2	837.2	0
2015	22.1	3,580.9	168.4	157,746.6	18.2	0
2016	21.9	2,045.2	0.7	330,600.2	103.6	0
2017	22	435.1	197.7	328,543.6	94.8	348.9
2018	21.9	2,370.7	409.6	487,155.3	33.1	729.3
2019	20.1	1,956.5	188.1	537,479.1	6.9	771.4
2020	19.1	1,308.2	127.3	546,711.2	57.3	620.9
2021	18	597.8	2,747.4	749,759.7	571.1	374.4
2022	18	303.4	1,456.1	365,124.9	341.2	120.9
2023	17.6	0	173.7	117,183.4	205.5	524.2

Source: Global Hunger Index (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

The linear regression model describing the dependence of the Global Hunger Index of Indonesia on agricultural and food imports from Ukraine is described by the following equation:

$$HGI_{Indz} = 4.730 - 0.168 * X_{1Indz} - 0.127 * X_{4Indz} \quad (5)$$

The regression model illustrates the notable ($R=0.917$) influence of HS04 imports from Ukraine on Indonesia's Global Hunger Index: a 1% rise in the independent variable results in a 0.168% drop in the dependent variable. The food security in Indonesia was also positively affected by the change in the volume of imports of HS12 "Oil seeds and oleaginous fruits...": a 1% increase in the imports of this commodity group contributed to a decrease in the Global Hunger Index by 0.127%. The coefficient of determination indicates that the Global Hunger Index of Indonesia in 2011-2023 was 84.1% dependent on changes in the volume of imports of HS04 and of HS10 from Ukraine, and 15.9% dependent on changers in other factors. The estimated value of Fisher's test exceeds its tabular value ($F(2.8) = 21.243$), which confirms the significance

of relationships between the dependent and independent variables. The level of statistical error does not exceed 1%, which indicates the acceptability of the obtained results of the regression analysis. The impact of imports of HS15 "Animal or vegetable fats and oils..." on the state of food security in Indonesia turned out to be statistically insignificant. The situation in 2022 was much worse. Imports fell by about 50% across all indicators. Bread prices rose by 20%, meat availability fell by 10%, and the number of undernourished persons grew by 5%.

The food security of Pakistan in the researched period deteriorated; the Global Hunger Index of this country has increased from 20.7 points in 2011 to 24.7 points in 2021. At the same time, in the medium-term period, there was a decrease in Global Hunger Index from 33.9 points in 2015 to 24.6 points in 2020. During this medium-term time-frame, the volume of imports from Ukraine to Pakistan in cereals, oil seeds and oleaginous fruits grew dynamically. Although the dynamics of these indicators had a stochastic nature, authors assume that the change in the Global Hunger Index for Pakistan was caused by the dynamics of imports volumes of these commodity groups (Table 3).

Table 3. Input data for a regression analysis of the impact of food exports from Ukraine on the change of the Global Hunger Index of Pakistan

Year	Dependent variable		Independent variable			
	Global Hunger Index		Value of Imports, thousands of USD			
	HGI_Ch	HS04 X_{1_Ch}	HS07 X_{2_Ch}	HS10 X_{3_Ch}	HS12 X_{4_Ch}	HS15 X_{5_Ch}
2011	12.2	2,288.1	145.7	744.5	361.4	0
2012	12	2,490.3	26.6	9,044.2	1,902.5	0
2013	10.1	3,655.2	80.1	64,465.1	2,555.5	292.4
2014	10.3	6,081.9	72.4	68,928.2	837.2	0
2015	22.1	3,580.9	168.4	157,746.6	18.2	0
2016	21.9	2,045.2	0.7	330,600.2	103.6	0
2017	22	435.1	197.7	328,543.6	94.8	348.9
2018	21.9	2,370.7	409.6	487,155.3	33.1	729.3
2019	20.1	1,956.5	188.1	537,479.1	6.9	771.4

Table 3, Continued

Year	Dependent variable		Independent variable			
	Global Hunger Index	HS04	Value of Imports, thousands of USD			
			HS07	HS10	HS12	HS15
	HGI_{Ch}	X_{1Ch}	X_{2Ch}	X_{3Ch}	X_{4Ch}	X_{5Ch}
2020	19.1	1,308.2	127.3	546,711.2	57.3	620.9
2021	18	597.8	2,747.4	749,759.7	571.1	374.4
2022	26.4	241.3	1,572.9	334,612.7	241.9	116.8
2023	26.6	113.9	782.5	45,401.3	10.7	0

Source: Global Hunger Index (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

The linear regression model describing the dependence of Global Hunger Index of Pakistan on food imports from Ukraine is described by the following equation:

$$HGI_{Pak} = 1.523 + 0.247 * X_{1Pak} - 0.037 * X_{3Pak} + 0.026 * X_{4Pak} \quad (6)$$

According to the regression model, HS04 imports from Ukraine had a substantial negative influence on Pakistan's Global Hunger Index between 2011 and 2023: a rise of 1% in the independent variable resulted in a 0.247% increase in the dependent variable. The imports of HS12 from Ukraine had a somewhat lesser negative influence on Pakistan's Global Hunger Index: for every 1% rise in the independent variable, the dependent variable increased by 0.026%. Pakistan's food security improved mainly because of a rise in the amount of HS10 "Cereals" imports from Ukraine: a 1% increase in the independent variable resulted in a 0.037% drop in the dependent variable. The correlation coefficient ($R = 0.924$) indicates a significant connection between changes in Pakistan's Global Hunger Index and food imports from Ukraine. The coefficient of determination suggests that variations in the amount of imports from Ukraine of HS04, HS10, and HS12 account for 85.5% of the change in the value of the Global Hunger Index, with the remaining 15.5% owing to other variables.

The estimated value of Fisher's test exceeds its tabular value ($F(3,7) = 13.749$), which confirms the strength of relationships between the dependent and independent variables. The level of statistical error does not exceed 1%, which indicates the acceptability of the obtained results of the regression analysis. As a result of the regression analysis, no statistically significant influence of the import of HS07 and HS15 from Ukraine on the state of food security of Pakistan was revealed. In the context of an integrated response to Russian aggression, the international community is closely monitoring the practical challenges and threats facing Ukraine. The war, condemned by a UN special commission, has had a serious impact on Pakistan, making it one of the 12 countries in the world most affected by rising energy prices and the food crisis. Ukraine is one of the largest suppliers of grain, corn, and other agricultural products to Pakistan. However, given the circumstances created by the conflict, food supplies are under significant threat. In the summer of 2020, Ukraine played an important role as a guarantor of food security for Pakistan, supplying 1.2 million tonnes of grain. However, the situation is now at risk due to the ongoing hostilities and uncertainty in the region. Ukraine's position as a key provider of agricultural products has been crucial to world food security, particularly in Asia, but the Russian

invasion in 2022 interrupted these shipments, resulting in a dramatic fall in food supplies and raising prices. As a result, nations such as Pakistan, Bangladesh, and Indonesia saw increased food insecurity, although China's Global Hunger Index improved, owing mostly to pre-war increases in Ukraine imports.

► Discussion

The study's findings revealed that Ukraine is a major provider of agricultural goods to foreign markets. Its main export commodities include tobacco, wheat, corn, vegetables, barley, pulses, sugar beet, fruits and sunflower. Agriculture is an important sector, providing employment for 14% of the country's population and accounting for a significant share of Ukraine's export earnings (Lin *et al.*, 2023). Food security and a stable supply of food resources to international markets are becoming increasingly important aspects of the global economy, especially given the growth of the world's population. Ukraine plays a key role in ensuring the food security of the global community due to its large supplies of crops to the world markets (Wellington *et al.*, 2023). Food security in China and Ukraine has some similarities due to the common challenges and characteristics of their agricultural sectors. Agriculture in both countries is an important component of the economy. It not only provides food for domestic consumption but is also a significant source of exports (Wu *et al.*, 2023). A colleague from China, Y. Jin (2023), noted that in recent years, consumption of agricultural products in China has been growing, which creates a certain pressure on exports, as the domestic market is becoming more attractive to local producers. The author stated that in 2021, China imported 164.539 mln tonnes of grain – 24.1% of the total volume (682.85 mln tonnes). In June 2022, China's wheat imports totalled \$200,485. In July, it increased to \$280,843. China's agricultural exports provide the country with significant revenues and contribute to global food security, but also pose challenges for China to maintain product quality, compete in the global market, and support sustainable agricultural development.

The Russian invasion of Ukraine in February 2022 had a serious impact on global food security. The imposed martial law restricted exports of staple foods, leading to a decline in exports and higher prices on international food markets (Hellegers, 2022). According to the Ukrainian government, the world market lost more than 20 million tonnes of Ukraine's projected food exports, and Ukraine supplied three times less agricultural and food products than planned for 2022 (Flockhart & Korosteleva, 2022). Unexpected restrictions and market instability may be

the main reasons for such large losses. Preventing such unforeseen situations and developing mechanisms to ensure food security in the face of geopolitical instability are becoming critical tasks for the international community. A similar situation can be noticed in Syria, where the Syrian economy has been devastated by a conflict that has touched both economic and social components of commercial activity, resulting in severe fluctuations and instability in the macroeconomic environment since 2011. H. Mkiyes (2023) discovered in his research that the exchange rate of the Syrian pound against foreign currencies was relatively stable from 2007 until the outbreak of the Syrian civil war. However, since 2011, the Central Bank of Syria has followed an exchange rate system, implying that it has not adopted a specific exchange rate system. The Syrian economy contracted at the second-largest rate in history in 2012, with a decline of 26.33%, which was nearly replicated the following year at 26.3%. The author concludes that the hostilities and destruction of infrastructure in Syria have led to a significant decline in the production of oil, gas, textiles, phosphates and other exports, which has forced many foreign companies to limit their cooperation with Syrian enterprises, restricted access to foreign markets and reduced the country's economic independence. The hostilities and the presence of rebel-controlled territories have created problems with transport and logistics for exports, which has led to delays and interruptions in supply, making Syria dependent on assistance from some foreign countries and international organisations.

The global food security crisis created by the Russia-Ukraine conflict necessitates an immediate national and global reaction to give relief in the near term, as well as long-term policy measures to diversify global food markets in order to build resilience and avoid repeating crises (Jagtap *et al.*, 2022). The stability of Ukraine's food supply to global markets has been challenged by restrictions on production and exports due to the conflict. This has led to a deterioration in the food situation in many countries that rely on Ukraine for their supplies. Certain countries are especially susceptible, such as those experiencing a weak and disproportionate economic recovery from the COVID-19 epidemic, those with conflict-affected and unstable economies, and low-income countries that rely heavily on food imports (Semenenko *et al.*, 2024). It is also important to consider regional and national specificities to develop effective food export and trade strategies (Mbah & Wasum, 2022). Some countries may be more vulnerable to changes in global markets due to their dependence on certain food commodities or supply partners. This necessitates comprehending and recognising regional and national vulnerabilities in order to justify urgent and long-term interventions (Leon *et al.*, 2022).

K.A. Abay *et al.* (2023) noted that to ensure the food security of Ukraine's partner countries, it is important to take coordinated measures to ensure a sustainable and reliable food supply. Expanding sources of supply, including other agricultural nations and regions, can help reduce dependence on a single supplier. In addition, developing domestic production and supporting agricultural enterprises can provide greater independence from external factors (Mukhametov *et al.*, 2023). Meanwhile, M. Al-Saidi (2023) expressed the importance of considering

regional and national specificities to develop effective food export and trade strategies. Some countries may be more vulnerable to changes in global markets due to their dependence on certain food products or supply partners. Meanwhile, S.K. Wegren (2023) has identified favourable production prospects for the 2022/23 winter plantings, but uncertain in Ukraine. In western Ukraine, where the fighting has halted activity on available land and spring crops such as corn, barley and sunflower seeds have been sown, difficulties have arisen due to remnants of war hindering agricultural operations. The author notes that disruptions to essential public services and localised shortages of inputs due to supply chain constraints have also negatively impacted agricultural activities. It is estimated that the area under main spring crops has decreased by around 20% in the government-controlled territory.

Having analysed the regression data, it can be concluded that Ukrainian exports to the main trade partners in Asia affect food security in different ways. The situation can have both positive and negative consequences. This suggests that engagement in international trade processes and active involvement in the global division of labour help to improve the food security component at the national level (Chorny & Chorna, 2017). However, it is important to understand that ensuring sustainable food security depends on a skilful balance: exporting surplus agricultural and food products after meeting domestic demand and importing the necessary volumes that cannot be produced in the country (Hall, 2023). Similar conclusions were reached by H. Hussein & M. Knol (2023), who argue that a country should be able to meet the needs of its domestic consumers in the first place, and only then export the surplus. If certain food products are not available for cultivation or production in the country, imports of these products are required to address the home demands of the people. This helps to maintain the country's food security, as it does not depend solely on domestic production, but can trade with other countries, ensuring a greater level of resilience and stability of the food market (Shahini *et al.*, 2023).

As a result, imports of agricultural and food products from Ukraine have a positive impact on the food security of some countries, including China, Indonesia, and Pakistan, but the study also points to the negative impact of high prices and limited imports on the affordability of products for the population. This aspect is particularly relevant due to the impact of geopolitical factors, such as war, on Ukraine's agricultural sector. It is noted that the effective development of international trade is a key tool for improving food security, but it is important to ensure the availability of the necessary products on the domestic market before exporting them. The situation highlights the need for careful analysis and management of foreign economic processes to maintain food security stability, especially in the context of the impact of conflicts and global events on the national agricultural market.

► Conclusions

The research examined Ukraine's role in global food security and showed that, while Ukrainian agricultural exports had a positive impact on the Global Hunger Index in certain countries, the conflict significantly disrupted

supply networks, undermining food security in the majority of places. There is a considerable correlation between Ukraine's agricultural exports and improvements in the Global Hunger Index of its primary trading partners. Specifically, the regression analysis revealed that a 1% increase in edible vegetable imports from Ukraine lowered China's Global Hunger Index by 0.125%, demonstrating that these exports improved China's food security. In contrast, a 1% increase in dairy product imports resulted in a 0.145% increase in China's Global Hunger Index, indicating a negative impact, probably owing to variances in local dietary preferences. However, the conflict in Ukraine resulted in a 60% decline in food exports in 2022, a 50% drop in imports to Asia, and a large increase in food insecurity in countries such as Pakistan, Bangladesh, and Indonesia.

The practical implications of this research are critical to global food security policy. Ensuring a consistent food supply from Ukraine has the potential to dramatically reduce the Global Hunger Index in key regions, particularly

Asia. Policymakers and international organisations should emphasise repairing and preserving Ukrainian export channels to mitigate the war's negative impact on global food markets and lower the possibility of hunger crises in vulnerable nations. This report stresses Ukraine's essential role in global food security and the need for concerted efforts to preserve its agricultural trade. Therefore, the increase in exports of food and agricultural products negatively affects the consumption of these products in the domestic market of Ukraine. This issue must be further researched in great detail to maintain the food security of Ukraine, especially considering the negative impact of war on the state of the national market and agricultural sector.

► Acknowledgements

None.

► Conflict of interest

None.

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Вплив українського імпорту на продовольчу безпеку торговельних партнерів

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► **Анотація.** Актуальність досліджуваної проблеми полягає в тому, що зміни на зовнішніх ринках можуть суттєво впливати на продовольчий сектор інших країн, а глобальна продовольча безпека, яка вимірюється комплексом індикаторів, зокрема Глобальним індексом голоду, є однією з головних загроз міжнародній економічній стабільності. Метою дослідження була оцінка взаємозв'язку між продовольчою безпекою Бангладеш, Китаю, Індії, Індонезії, Пакистану, Шрі-Ланки та В'єтнаму і динамікою їхнього імпорту сільськогосподарської та харчової продукції з України. У дослідженні було використано низку методів, включаючи аналіз динаміки Глобального індексу голоду найбільших імпортерів України, структурний та регресійний аналіз імпорту сільськогосподарської продукції з України. Результати дослідження виявили позитивний вплив імпорту продовольства з України на продовольчу безпеку низки країн. Зокрема, дослідження показало, що імпорт овочів з України має позитивний вплив на продовольчу безпеку Китаю, тоді як українське молоко, молочні продукти, яйця птиці, натуральний мед, насіння олійних культур та плоди олійних культур допомагають забезпечити продовольчу безпеку Індонезії. Імпорт зернових з України також має позитивний вплив на продовольчу безпеку Пакистану. Проте дослідження не підтвердило статистично значущого зв'язку між динамікою Глобального індексу голоду та імпортом продовольства з України до Бангладеш, В'єтнаму, Індії, Шрі-Ланки та В'єтнаму у період з 2011 по 2023 роки. Практичне значення дослідження визначається розумінням впливу українського імпорту на продовольчу безпеку торговельних партнерів та необхідністю розробки стратегій диверсифікації поставок і стимулювання внутрішнього виробництва для забезпечення стійкості та сталості продовольчого сектору цих країн

► **Ключові слова:** міжнародна торгівля; стійкість; Глобальний індекс голоду; регресійний аналіз; міжнародні ринки



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Wine production in Ukraine: Challenges, opportunities today

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► **Abstract.** The relevance of the study is driven by the need to overcome the challenges facing Ukraine's viticulture and wine production sectors, such as the lack of consistent state policy, high tax barriers, competition with imported products, and the negative impact of military actions, to ensure their sustainable development and recovery. The study aimed to analyse current trends in Ukrainian viticulture and wine production, identify key problems, and develop proposals for their resolution to stimulate the sector's development in the context of European integration and wartime conditions. The research focused on assessing the current state of viticulture and wine production in Ukraine using statistical methods to analyse production indicators and structural changes in the sector. The study revealed a significant reduction in the area of fruit-bearing vineyards and a decrease in grape production from 1990 to 2023. It was found that military actions led to additional losses of vineyards and winemaking capacities, negatively impacting the sector's development. Structural changes in the winemaking industry were also analysed, and their implications for the national economy were summarised. Despite the difficulties, there has been a growing interest in Ukrainian wine in the domestic market and the beginning of export recovery from 2014 to 2023, indicating the potential for the sector's recovery and growth. The study's results can be used by government authorities and entrepreneurs to develop policies supporting viticulture and wine production, aimed at reducing import dependency and increasing the competitiveness of Ukrainian wine products

► **Keywords:** wine; state support; European integration; economic challenges; sector development; innovative technologies

► Introduction

Ukraine has rich traditions in wine production and unique grape varieties that stand out for their distinctiveness. Viticulture and wine production have always been important economic activities in Ukraine. Over the post-reform period of agricultural development, the Ukrainian viticulture sector has undergone significant changes. However, due to the lack of consistent government policy, the wine production industry has struggled to function effectively. One of the main challenges in Ukraine's wine production sector has been insufficient state support. Wine production was not considered a priority for state policy for a long time. In Ukraine, winemakers have operated under Soviet-era excise administration standards. Notably, in some European Union countries, there is no licensing for natural wine production at all, while in most other cases, the licensing process is significantly simplified. Unlike Ukraine, countries such as Moldova, Georgia, and EU member states have considered wine production an important part of rural prestige and entrepreneurship development, which

includes the growth of small wineries, the reduction of the informal economy, and the creation of new jobs in rural areas (Chamber of Commerce and..., n.d.; Between Barcelona and Ochakiv..., 2021).

Modern literature on wine production examines various aspects, ranging from innovative methods for improving grapes quality, and geographic designation policies, to intercultural wine consumption. N. Zelenska *et al.* (2023) focused on the implementation of innovative methods to improve grapes quality. The authors studied the effect of a live chlorella suspension on the growth and development of grafted Cabernet Sauvignon grape seedlings. J.M. Alston & D. Gaeta (2021) analysed the historical development of European wine policy within the Common Agricultural Policy (CAP) framework and the economic consequences of technological regulations related to wine production. The authors noted that while these regulations had a positive educational impact on producers and consumers of wine, they were less valuable due to the availability of

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alternative information sources and the inefficiency of certain regulations, particularly yield economically ineffective restrictions. L. Gutsalenko *et al.* (2020) focused on the development of the wine production sector in Ukraine, particularly organic viticulture. The studies emphasised the need for standardisation and certification to establish and fix the qualitative characteristics of wine, as well as analysed the impact of various factors on the cost of organic production.

G. Szolnoki & G. Totth (2020) studied consumer behaviour differences and sales channel structures in these countries. The results showed significant differences not only in wine preferences but also in the use of sales channels, providing important information for producers and marketers. M. Hermans & D. Finchelstein (2020) analysed the internationalization strategies of seven Argentine companies from various sectors, including wine production. The authors emphasise the importance of developing strategic capabilities for success in international markets. N. Jiménez-Asenjo & D.A. Filipescu (2019) examine the marketing strategies of Spanish winemakers in the Chinese market. The authors found that external factors force companies to adapt their strategies, while internal factors determine the standardization of their product range. A. Kovalyov *et al.* (2022) researched innovative approaches to the clustering of viticulture and wine production enterprises, identifying problems and development prospects, and substantiated the creation of a cluster in the cross-border region of Ukraine-Moldova as a promising direction for restructuring.

V.A. Castro *et al.* (2018) studied the process of building and operating sectoral brands in the Brazilian wine sector, identifying the impact of participation in international fairs on the spread and image of the brand, and justifying the need for investment in internal projects to develop the national market. M. Vázquez-Fariñas & J.M. Rosso (2017) explored the development of viticulture and wine production in the city of Cádiz in the 19th and 20th centuries, revealing the transformation of the wine business into a modern agribusiness and substantiating the significance of wine production for the city's economy.

The increase in studies on macro- and microeconomic processes in wine production, as well as the expansion of thematic areas, including wine tourism and collaboration between winemakers and wine producers, is reflected in the works of Ö. Güzel *et al.* (2021). Wine tourism is a key component of the wine production industry, actively supporting its development (Aleffi *et al.*, 2020; Fuentes-Fernández *et al.*, 2022). This type of tourism includes trips to wine regions, involving visits to wine cellars, participation in tastings and festivals, as well as promoting local wines and cultural traditions.

These studies provide valuable insights into various aspects of the wine production industry, including economic, environmental, cultural, and strategic factors that influence the development and functioning of this important sector in different countries. However, modern trends in the development of wine production in Ukraine require detailed consideration. The objective of the study was to conduct a comprehensive analysis of current trends in Ukraine's viticulture and wine production sector in the context of European integration processes and the

impact of martial law. The study's objectives are as follows: identifying key challenges faced by the industry, developing practical recommendations to overcome these challenges and stimulate sustainable development, and evaluating the effectiveness of existing strategies for maintaining the competitiveness of Ukrainian wine production in domestic and international markets.

► Materials and methods

The study of current trends, challenges, and prospects for the development of viticulture and wine production in Ukraine was based on the use of a comprehensive set of scientific methods that enable in-depth analysis and provide well-grounded recommendations to stimulate the industry's development in the context of European integration and martial law. Various methods of scientific inquiry, such as analysis, synthesis, comparison, and generalisation, were used to investigate the issue thoroughly and propose scientifically substantiated recommendations.

Analysis and synthesis were used to examine existing literature and scientific works that reveal current trends in viticulture and wine production. These methods helped form a holistic view of the sector's problems and opportunities. The synthesis method generated summarised conclusions regarding the industry's status, highlighting key areas for development and identifying problem zones. The systems analysis method was applied to explore the interconnections between different components of viticulture and wine production, including production, market demand, regulatory frameworks, and export opportunities. This allowed for a comprehensive assessment of the interrelated factors affecting the industry's development and helped identify potential growth points and risks. The systemic approach was also used to evaluate the effectiveness of government support programs for the industry and their alignment with EU requirements.

The case study method was employed for an in-depth examination of successful examples from craft wineries, such as Kalyus Winery and Beykysh Winery (Wines of Ukraine. Podillia..., 2023; Beykush Winery official website, n.d.). This approach enabled the study of specific cases that demonstrated the effective use of marketing strategies, wine-tasting tours, wine clubs, and socially-oriented initiatives for promoting wine products in domestic and international markets. The content analysis method was applied to examine materials from mass media, industry publications, and official statements related to the development of viticulture and wine production in Ukraine. The implementation of these methods provided a comprehensive understanding of the current state of viticulture and wine production in Ukraine, identifying key trends and challenges. Additionally, it facilitated the development of well-founded recommendations for the further advancement of the industry under the conditions of European integration and martial law.

Data from the Official website of the State Statistics Service of Ukraine (n.d.) was used to analyse vineyard areas, grape and wine production volumes, and structural changes in the industry. Some data for 2022-2023 became unavailable or confidential due to martial law and related restrictions. Information was also obtained from official websites of leading industry associations, such

as Ukrvinprom (Ukrvinprom, n.d.), the International Organisation of Vine and Wine (International Organisation of Vine..., n.d.), and industry journals and web platforms specialising in viticulture and wine production. Additionally, regulatory documents governing the development of viticulture and wine production in Ukraine, including laws, government decrees, state support programs, EU association agreements, and other regulatory acts defining the framework conditions for the industry's operation, were analysed. To study the scientific approaches and methods applied in viticulture and wine production, works of Ukrainian and other authors published in periodicals, monographs, and conference proceedings were reviewed.

► Results

With the development of the market economy in Ukraine, new winemakers emerged aiming to transform Ukrainian wine production and demonstrate that high-quality wine can be produced in the country. While climatic conditions were favourable for such production, legislative simplifications were required to facilitate business operations. The lack of effective financing mechanisms and government programs to support the wine production industry significantly constrained its development. Additionally, tax regulations and high entry barriers to the market further hindered progress in wine production. Ukrainian wine remained largely unknown abroad, and Ukraine's reputation as a wine-producing country was underdeveloped (Why wine doesn't sparkle, 2023).

Since 2014, Ukrainian viticulture has experienced a clear downward trend, evidenced by the reduction of vineyard areas by 14.0 thousand hectares and a decrease in the gross production of grapes by 171.5 thousand tonnes (Official website of the State..., n.d.). This decline is primarily linked to the annexation of the Crimean wine production region. In addition to geopolitical shifts, the development of wine production was hampered by bureaucratic procedures. Until 2018, obtaining a wine production licence required collecting 160 permits. However, this procedure was simplified in 2018 (Between Barcelona and Ochakiv..., 2021).

Despite losing such a significant wine production region, Ukraine's wine production sector has seen dynamic development in recent years. Since 2015, the direction of Ukraine's viticulture and wine production has shifted, with the emergence of numerous small producers who could potentially serve as the foundation for larger enterprises. Ukrainian wine began receiving international recognition, and craft producers started to encourage local consumers to favour domestic winemakers. Grape growers, winemakers, oenologists, and sommeliers significantly improved their professional skills, contributing to the industry's development. By 2021, there were about 266 enterprises in Ukraine involved in grape growing and wine production, including 125 wine production enterprises and 29 small wine producers. Each hectare of vineyards employed an average of 33 permanent workers, with the average number of employees per enterprise at 255, demonstrating high employment levels in this economic sector compared to others (Discussion of Ukraine's wine..., 2023). However, in February 2022, the dynamic development of Ukraine's wine production industry was interrupted. Since the start of the full-scale war, Ukraine's wine

production industry has suffered significant losses. Many vineyards and production facilities fell under occupation or were threatened by shelling, and some were contaminated with hazardous materials. A significant number of industry workers, winemakers, were forced to leave their homes (Ukraine needs a state program..., 2023). Russian shelling, the looting of wineries, the mining of vineyards, and the destruction of wine warehouses have inflicted irreparable damage on the sector. Roman Zayats, founder of the media project "Sertsevin" and the special project "Svoje Vino," was among the first to document Ukrainian wineries after the full-scale invasion began (Wine among mines and rockets, 2023). In April 2022, he and his team conducted a two-week expedition, resulting in the documentary film "Wounded Land," produced in collaboration with Ukrainian, American, and Polish partners. Initially planned as a series on Ukraine's wine culture, the project shifted its format due to the war. The first location documented was the wine warehouse of the Goodwine store in Stoyanka, which had been shelled, leaving only a few hundred charred bottles. The team also visited Wineldea winery in Yasnohorodka, which had been struck just a week before filming, but the wine remained intact. As a result of Russian actions, the Kherson Chateau of Prince Trubetskoy, with over 120 years of history, was severely damaged. Although the area where the winery is located has been de-occupied, it is currently impossible to resume production due to extensive damage from the fighting and the ongoing threat of shelling.

Russian aggression has also complicated the supply of components, which are now imported from abroad. The closure of the bottling plant in Hostomel forced producers to purchase bottles from Moldova and other countries. Logistical issues have also complicated orders for corks from Portugal, necessitating the use of intermediaries (Development of viticulture in Odesa region..., 2023). Due to the fighting, the area of fruit-bearing vineyards in Ukraine has decreased by one-third, posing serious challenges for winemakers. Overall, Ukraine's wine production sector may lose nearly half of its vineyards due to Russia's invasion, as most vineyards are located in the southeastern regions of high risk. Restoring destroyed perennial plantings will take considerable time, as it takes five years from planting to the first harvest. The production of grape seedlings has also decreased.

Let us take a closer look at the statistical information on the area of fruit-bearing vineyards (Fig. 1). The graph illustrates the dynamics of vineyard areas (all categories of farms) in Ukraine from 1990 to 2023. The categories examined include all farms, agricultural enterprises, and household farms. In 1990, the total area of vineyards (across all categories of farms) exceeded 143 thousand hectares. From 1990 to 2010, there was a sharp decline to approximately 68 thousand hectares. The area then stabilised, but from 2014, following the annexation of the Autonomous Republic of Crimea, there was another significant decline, reaching below 44 thousand hectares, and subsequently dropping further to 25.2 thousand hectares by 2023 (Official website of the State..., n.d.). In the period from 1990 to 2023, the area of fruit-bearing vineyards decreased by 82.4%. Compared with 2010, the decline is 62.7%, with 2015 – 39.7%, and with 2021 – 27.4%.

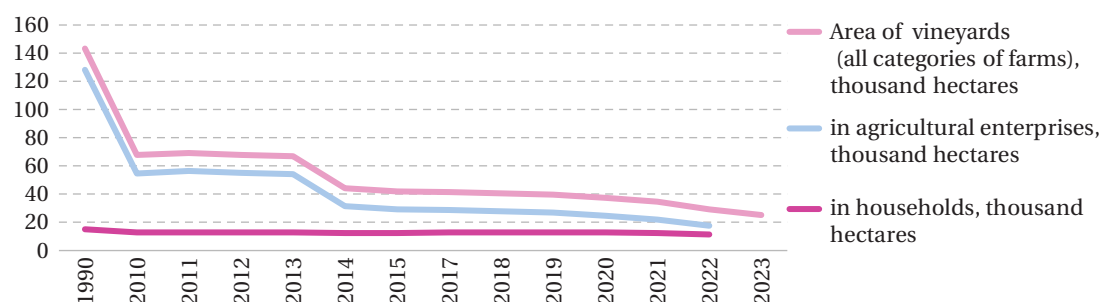


Figure 1. Area of vineyards in bearing age, thousand hectares

Source: Official website of the State Statistics Service of Ukraine (n.d.)

The area of vineyards in agricultural enterprises has significantly decreased since 1990. In 2014, there was again a notable decline, consistent with the overall trend. By 2023, the area had reached only 17.6 thousand hectares. Analysis of the vineyard area in household farms indicates that this category has the smallest vineyard area compared to other categories. From 1990 to 2010, the area declined from approximately 15 thousand hectares to around 11 thousand hectares by 2023.

From this figure, the main conclusions are that the reduction in the vineyard area began in the 1990s and significantly intensified after 2014. The most substantial decrease is observed in agricultural enterprises, reflecting the overall trend of loss of industrial vineyards. While vineyards in household farms have also diminished, the rate of this decline has been less steep. The annexation of

Crimea (2014) and the full-scale invasion (2022) have significantly impacted the overall area of vineyards, posing a considerable challenge for the Ukrainian wine production industry. This data highlights the significant challenges faced by the industry in Ukraine over the past decades.

Overall, during the period from 1990 to 2022, there has been a positive trend towards increased grape yields, which may indicate producers' adaptation and the implementation of new technologies. Increasing yields requires investment in new technologies, state support, and the modernisation of production processes (Topov, 2017). The adoption of modern agro-technologies and improved management could help enhance production efficiency and stabilise the sector. Regarding agricultural enterprises, there was an increase in yields until 2018, followed by a significant downturn (Fig. 2).

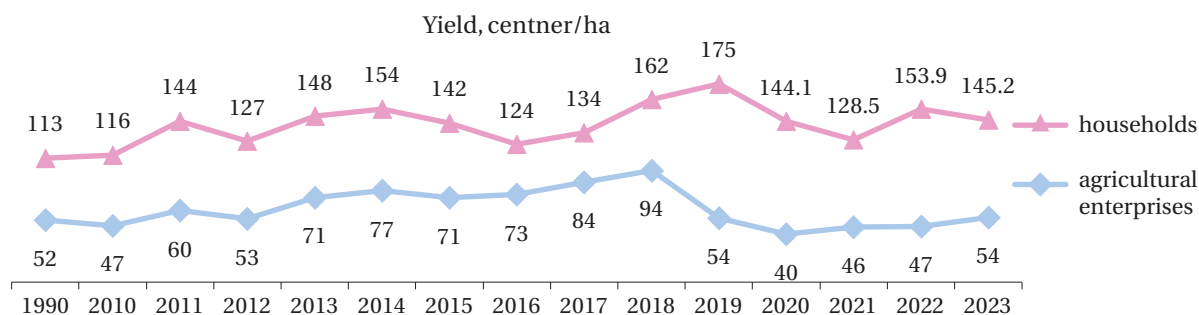


Figure 2. Yield per hectare of plantings, centners

Source: Official website of the State Statistics Service of Ukraine (n.d.)

From 1990 to 2023, there has been a significant decline in grape production in Ukraine. The total volume of grape production (across all categories of farms) was 836 thousand tonnes in 1990; by 2010, this had decreased dramatically to 408 thousand tonnes (a reduction of half). Following this, production volumes fluctuated, peaking in 2011 (522 thousand tonnes), 2013 (575 thousand tonnes), and 2018 (468 thousand tonnes). A certain upward trend in this indicator was disrupted from 2010 to 2013. In 2014, compared to the previous year, grape production decreased by 34% of the total volume. This was caused by the occupation of the territory of the Autonomous Republic of Crimea, where a significant number of agricultural enterprises specialised in grape cultivation were located. The market supply structure for grapes has also been impacted, which has increasingly

been shaped by household farms in recent years. Since 2018, production has gradually decreased again, reaching 232 thousand tonnes by 2023.

Analysing grape production in agricultural enterprises, it should be noted that agricultural enterprises produced a significant portion of the grapes in 1990, but their contribution has gradually declined since that time. In 2018, the share of production from agricultural enterprises still accounted for more than half of the total volume, after which a decrease was observed.

Grape production in household farms: household farms made a significant contribution to grape production, especially from 2010 to 2018. During the period from 2010 to 2013, the share of grapes grown in household farms was about 35%, increasing to 44.7% in 2014, and reaching 70% by 2023 (Fig. 3).

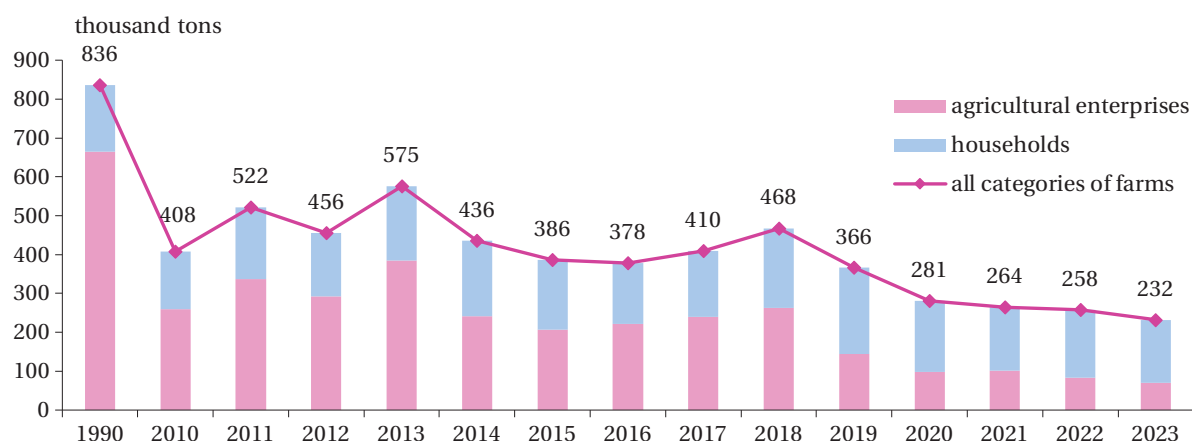


Figure 3. Grape cultivation in Ukraine, thousand tonnes

Source: Official website of the State Statistics Service of Ukraine (n.d.)

It is important to note that viticulture and wine production are vital sectors that contribute to job creation, especially in rural areas. For example, in the rural areas of Odesa region, viticulture provides between five to seven thousand permanent jobs, and during the harvest season,

this number doubles. Regarding processing, similar declining trends were also observed here (Fig. 4). The graph illustrates the changes in the volumes of grape processing into wine materials and the production of wine materials in Ukraine from 2018 to 2023.

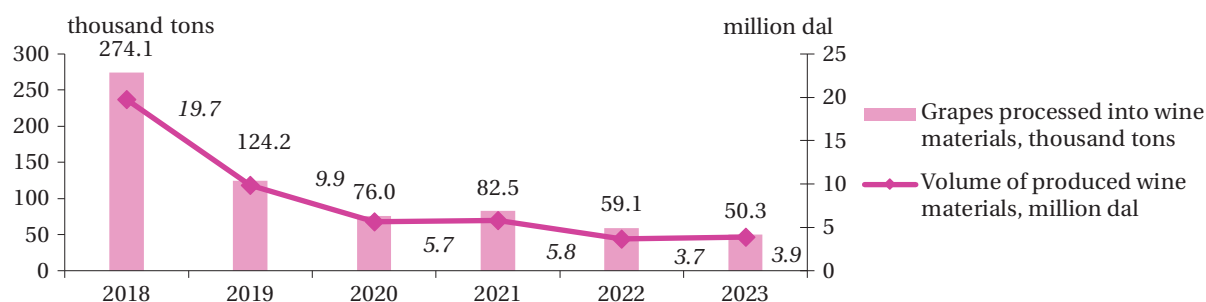


Figure 4. Dynamics of grape processing and production of wine materials in Ukraine

Note: excluding the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Let us examine the trends in more detail: 2018-2019: a sharp decline is observed in grape processing volumes (by 149.9 thousand tonnes) and the production of wine materials (by 9.8 million dals); 2019-2020: the decline in grape processing continues (by 48.2 thousand tonnes) and in the production of wine materials (by 4.2 million dals), although the rate of decline is slowing down; 2020-2021: a slight increase in grape processing volumes is noted (by 6.5 thousand tonnes) and stabilisation in the production of wine materials (an increase of 0.1 million dals); 2021-2023: the trend of decreasing grape processing volumes continues (from 82.5 thousand tonnes in 2021 to 50.3 thousand tonnes in 2023). Production of wine materials also decreases (from 5.8 million dal in 2021 to 3.9 million dals in 2023).

The reduction in grape processing volumes and production of wine materials may be linked to several factors:

primarily, the decrease in vineyard area as a result of economic and political factors; economic difficulties, leading to reduced demand for wine materials in both domestic and international markets; and geopolitical factors, including the annexation of Crimea, military actions in eastern Ukraine, and the full-scale invasion.

Full-cycle production enterprises, which encompass all stages from raw material cultivation to wine production and sales, ensure the independent functioning of their production capacities. In contrast, farming enterprises face challenges in selling the technical grape varieties they cultivate. In Ukraine, technical grape varieties are predominantly grown, and there is a shortage of table grape varieties, particularly raisins. Leading varieties include Aligoté, Cabernet Sauvignon, Muscat (white, pink, Ottonel, etc.), Rkatsiteli, and Chardonnay (Table 1).

Table 1. Grape processing into wine materials, t

Total grape processed	2018 274,052	2019 124,227	2020 75,982	2021 82,464	2022 59,121	2023 50,333
by variety						
Aligoté	29,001	14,056	7,204	10,180	9,722	7,461

Table 1, Continued

Total grape processed	2018 274,052	2019 124,227	2020 75,982	2021 82,464	2022 59,121	2023 50,333
Bastardo Magaracha	7,772	2,874	2,321	2,082	κ	κ
Cabernet Sauvignon	25,939	12,891	9,862	11,084	5,244	5,394
Merlot	14,803	6,662	3,459	4,862	3,620	2,493
Muscat (white, pink, Ottonel, etc.)	19,789	8,392	7,942	6,788	4,402	4,825
Odesa Black	7,462	3,110	2,416	1,705	1,956	2,086
Pinot (white, black, grey)	12,123	5,061	4,598	3,282	1,903	2,883
Riesling (Rhine, Italian)	12,401	8,484	5,342	4,833	3,777	2,161
Rkatsiteli	15,396	5,459	3,831	4,741	3,856	3,385
Pervenys Magaracha	... ²	κ	-	-	-	-
Podarok Magaracha	... ²	κ	-	-	-	-
Saperavi (Northern)	10,746	4,353	3,302	4,095	3,772	2,610
Sylvaner	... ²	κ	κ	-	-	-
Sauvignon (white, green)	12,249	6,031	4,131	4,224	3,700	2,420
Sukholimansky	4,464	954	1,148	1,351	716	460
Traminer Rosé	4,783	1,893	1,198	979	1,063	1,055
Feteasca (Leanka)	4,242	2,005	κ	κ	κ	κ
Citronny Magaracha	... ²	κ	κ	κ	-	-
Chardonnay	23,757	11,357	7,537	10,934	5,612	4,486
Others	64,751	30,281	10,749	9,726	7,054	6,705

Note: κ – data not available

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Varietal analysis indicates that different grape varieties exhibit a similar downward trend, although there are some exceptions. For instance, the varieties Aligote, Cabernet Sauvignon, Muscat, and Chardonnay maintain relatively high processing volumes compared to other varieties. A comparative analysis of 2018 and 2023 showed that the varietal structure of grape processing in Ukraine has changed, specifically with increases in the processing volumes of popular grape varieties such as Aligote (up by 5% from 11% in 2018 to 16% in 2023, indicating a rise in its

popularity and processing), and Muscat (up by 3% from 7% in 2018 to 10% in 2023). The share of the Others category decreased from 24% in 2018 to 14% in 2023, suggesting a concentration of processing on more popular or economically viable varieties. The shares of Cabernet Sauvignon, Merlot, Sauvignon, Riesling, Pinot, and Chardonnay remained relatively stable with minor fluctuations. The varieties Bastardo Magaracha and Feteasca were no longer mentioned in 2023, which may indicate a reduction in their processing or exclusion from industrial use (Fig. 5).

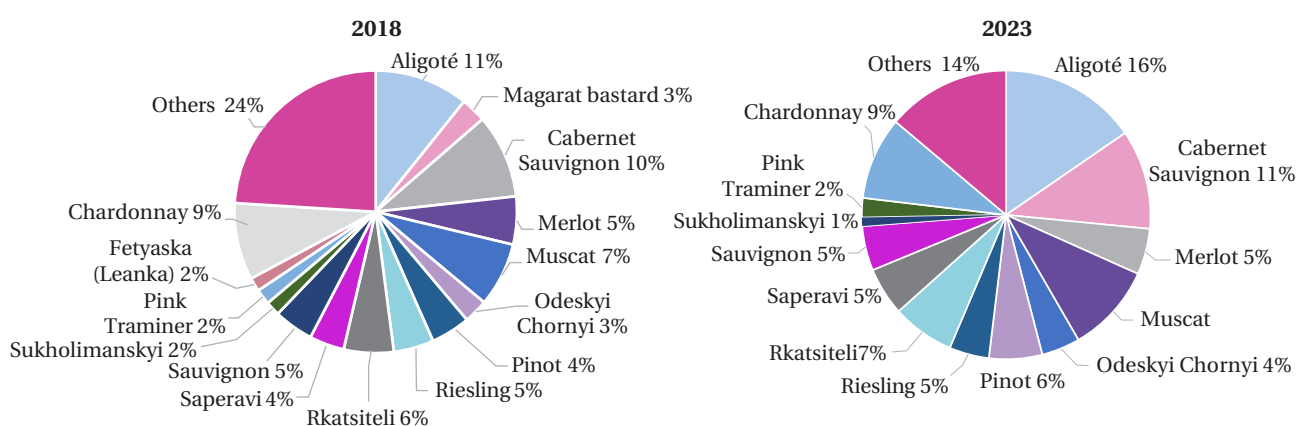


Figure 5. Grape processing varietal structure in Ukraine, %

Note: excluding the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol

Source: Official website of the State Statistics Service of Ukraine (n.d.)

The highest volume of wine material production was observed in 2018 (19,750 thousand dal). After this, production gradually declined, reaching a minimum in 2022 (3,671 thousand dal). In 2023, a slight recovery was noted, rising to 3,861 thousand dals. The distribution by category shows that: the production volumes of champagne and

sparkling wines significantly decreased from 5,079.9 thousand dal in 2018 to 1,157.2 thousand dals in 2023. For brandy wine materials, the highest production volume was in 2018 at 4,990.2 thousand dals, but it sharply declined to 267.4 thousand dals in 2023. Table wines remain the most significant category in terms of volume, but also show a

downward trend, falling from 9,279.1 thousand dal in 2018 to 2,381.9 thousand dals in 2023. Fortified wines experienced fluctuating production, peaking at 614.8 thousand dals in 2021, before decreasing to 328.1 thousand dals in

2023. The use of rectified spirit reached its highest level in 2018 (67.6 thousand dal), after which it fell to 21.8 thousand dals in 2021. Data for 2022-2023 was unavailable at the time of the publication (Table 2).

Table 2. Production of wine materials by product assortment, usage, and stocks of rectified spirit

	The volume of produced wine materials, thousand dal					
	2018	2019	2020	2021	2022	2023
Total wine materials	19,750	9,883	5,683	5,815	3,671	3,861
Of which:						
For champagne and sparkling wines	5,079.9	18,95.2	1,360.6	1,873.0	888.3	1,157.2
Cognac	4,990.2	24,43.7	230.8	211.8	k	267.4
Table wines	9,279.1	50,85.9	3,585.8	3,092.9	2,686.6	2,381.9
Fortified wines	279.9	311.7	464.8	614.8	k	k
For maturation (table wines)	k	118.9	k	k	k	k
For maturation (fortified wines)	k	-	-	-	-	-
Other	66.3	k	k	-	k	k
Rectified spirit used	67.6	58.0	51.3	21.8	k	k
Availability of rectified spirit as of 1 December 2023	k	-	k	-	k	-

Note: k – data not available

Source: Official website of the State Statistics Service of Ukraine (n.d.)

The Odesa region is the leader in wine production in Ukraine, with a production volume of 2,320 thousand dal of wine and the processing of 67,037 thousand tonnes of grapes in 2021. The region was home to 49 wineries and 200 enterprises, engaged in grape processing and cultivation, accounting for over 60% of the country's wine production. The largest vineyard areas are concentrated in Bessarabia. Odesa wines, due to the unique climate, can resemble French, Italian, and Spanish wines. Currently, negotiations are underway for the export of Odesa sparkling wine to the USA and European countries (Official website of the State..., n.d.).

The average purchase price of grapes for processing generally showed a trend of increasing from 2018 to 2023, reflecting the overall rise in prices in the industry (from 5,463.3 UAH per tonne to UAH 7,622.4 UAH/tonne in 2021

and to 8,337.7 UAH/tonne in 2023), although price reductions were observed in 2019 (5,453 UAH/tonne) and 2022 (7,531.4 UAH/tonne).

Price increases by variety: Traminer Rosé – the price rose from 6,164.9 UAH per tonne in 2018 to 10,619.3 UAH per tonne in 2023; Pinot (white, black, grey) – the price increased from 5,706.0 UAH per tonne in 2018 to 9,689.6 UAH per tonne in 2023; Odesa Black – the price rose from 5,280.1 UAH per tonne in 2018 to 9,033.1 UAH per tonne in 2023; Sauvignon (white, green) – the price rose from 5,745.1 UAH per tonne in 2018 to 8,384.1 UAH per tonne in 2023; Riesling (Rhine, Italian) – the price rose from 5,338.0 UAH per tonne in 2018 to 8,241.2 UAH per tonne in 2023; Sukholimansky – the price rose from 4,446.9 UAH per tonne in 2018 to 7,716.2 UAH per tonne in 2023 (Table 3).

Table 3. Average purchase price, UAH per tonne

	2018	2019	2020	2021	2022	2023
Total grape processed	5,463.3	5,453.7	6,608.4	7,622.4	7,531.4	8,337.7
by variety						
Aligoté	5,695.6	4,973.7	6,689.0	9,176.6	7,233.2	8,018.1
Bastardo Magaracha	5,720.7	7,012.8	8,506.5	9,652.3	k	k
Cabernet Sauvignon	5,890.8	4,951.9	7,026.9	7,663.7	7,793.0	8,477.8
Merlot	5,612.8	4,760.7	7,499.9	6,247.9	7,103.1	8,396.9
Muscat (white, pink, Ottonel, etc.)	5,927.3	5,821.3	6,665.2	8,153.6	7,358.2	7,639.6
Odesa Black	5,280.1	5,107.7	6,035.3	7,483.7	7,453.3	9,033.1
Pinot (white, black, grey)	5,706.0	5,923.4	6,386.4	11,037.3	8,780.6	9,689.6
Riesling (Rhine, Italian)	5,338.0	4,113.0	5,566.6	5,980.1	5,027.1	8,241.2
Rkatsiteli	5,049.3	5,638.6	7,887.3	7,554.2	7,222.7	8,627.9
Pervenets Magaracha	-	k	-	-	-	-
Podarok Magaracha	-	k	-	-	-	-
Saperavi (Northern)	4,705.0	5,697.5	7,720.1	6,875.9	8,401.0	8,635.0
Sylvaner	k	k	-	-	-	-
Sauvignon (white, green)	5,745.1	4,758.1	6,439.8	6,825.1	7,169.9	8,384.1
Sukholimansky	4,446.9	3,895.5	4,655.6	4,222.5	5,569.1	7,716.2

Table 3, Continued

	2018	2019	2020	2021	2022	2023
Total grape processed	5,463.3	5,453.7	6,608.4	7,622.4	7,531.4	8,337.7
Traminer Rosé	6,164.9	6,071.5	6,482.4	6,608.3	8,647.2	10,619.3
Feteasca (Leanca)	4,436.5	2,957.6	k	k	k	k
Citronny Magaracha	-	-	-	-	-	-
Chardonnay	5,721.1	5,302.5	7,221.0	7,426.6	7,783.5	8,583.4
Others	5,119.1	6,057.9	5,259.0	7,502.5	7,377.9	6,834.9

Note: k – data not available

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Thus, prices for all major grape varieties have significantly increased over the analysed period, which might be related to inflation, rising production costs, increasing demand for wine materials, and other economic factors. The most substantial price increases were observed in varieties of high demand or less common. As for technical grape varieties, Aligoté, Cabernet Sauvignon, Muscat, Saperavi, Merlot, Chardonnay, Rkatsiteli, and Riesling, their selling price ranges from 8 to 12 UAH per kilogram. Regarding the export of grape wine from Ukraine under

code 2204 “Grape wines, including fortified wines; grape must”, there is a trend of fluctuation from 2010 to 2018, when an average of 48 million litres was exported. This trend was disrupted in 2019, leading to a collapse in export volumes. Over the next five years, a total of 48 million litres were exported only, averaging 9.6 million litres per year. In 2022, the onset of the full-scale invasion resulted in a further halving of export volumes; however, in 2023, Ukrainian producers began to restore pre-war export levels (Table 4).

Table 4. Dynamics of grape wine export and import

	Export			Import		
	Volume, million litres	Value, thousand USD	Price per litre, USD	Volume, million litres	Value, thousand USD	Price per litre, USD
2010	63.65	63	1.00	32.8	69	2.11
2011	33.23	45	1.36	50.0	106	2.12
2012	44.85	51	1.14	33.3	106	3.17
2013	60.98	71	1.16	34.7	127	3.66
2014	45.41	35	0.77	27.3	96	3.50
2015	61.23	38	0.62	23.3	56	2.41
2016	31.57	25	0.78	43.2	85	1.98
2017	44.29	36	0.81	37.9	104	2.75
2018	46.93	40	0.85	37.9	125	3.31
2019	6.83	12	1.75	45.0	147	3.26
2020	14.4	13.1	0.91	53.2	179.2	3.37
2021	10.4	16.4	1.58	64.0	215.4	3.37
2022	5.7	8.7	1.52	36.9	117.8	3.19
2023	10.7	8.8	0.83	51.4	180.1	3.50

Source: Official website of the State Statistics Service of Ukraine (n.d.)

A negative trend is observed as export volumes continue to decline, while imports have reached record highs in recent years: 53.2 million litres valued at USD 179.2 thousand in 2020, 64.0 million litres valued at USD 215.4 thousand in 2021, and 51.4 million litres valued at USD 180.1 thousand in 2023. Additionally, wine is exported at an average price of 1 USD per litre, which is half the cost of imports. Export prices have varied, with the lowest recorded in 2015 (USD 0.62) and the highest in 2019 (USD 1.75). For imports, the price per litre ranged from USD 1.98 to USD 3.66 in 2013, and USD 3.50 in both 2014 and 2023.

The peak volumes and values for export were recorded in 2010 (63.65 million litres worth USD 63 thousand) and 2013 (60.98 million litres worth USD 71 thousand). The lowest export volumes occurred in 2019 (6.83 million litres worth USD 12 thousand) and 2022 (5.7 million litres worth USD 8.7 thousand). There was a notable increase

in both volumes and values of exports in 2023, reaching 10.7 million litres and USD 8.8 thousand. The minimum import volumes and values were in 2015 (23.3 million litres worth USD 56 thousand) and 2014 (27.3 million litres worth USD 96 thousand). Throughout the entire period, import volumes have consistently exceeded export volumes, indicating Ukraine's dependence on imported wines. Imported wine is significantly more expensive than exported wine.

Let us examine these issues in more detail. Grape and wine producers in Ukraine face numerous economic challenges, including competition from imported wines and fluctuations in the market. The high volume of imports compared to exports highlights the need to enhance the competitiveness of wines produced in Ukraine, both in the domestic market to reduce dependence on imports and in international markets.

Pricing policy also plays a crucial role; since the cost of imported wine is significantly higher than that of exported wine, there are opportunities to increase the added value of Ukrainian wine products. This data underscores the importance of developing strategies to support and grow the wine industry, particularly through improving product quality and expanding export markets. In 2023, the main countries importing Ukrainian wine were Romania, accounting for 62% of the total export volume, followed by Moldova (14.6%), Kazakhstan (3.5%), Poland (2.6%), Turkey (2.2%), Latvia (1.6%), the USA (1.4%), and Israel (1.1%). The share of exports to other countries was less than 1%, and these countries were not included in the sample.

For leaders of the wine industry, such as France, Italy, and Spain, Ukraine is a relatively young wine producer. However, historically, viticulture in Ukraine has roots that span several millennia (Development of viticulture in Odesa region ..., 2023). Modern Ukrainian wines are already

gaining recognition and awards in international competitions, attesting to their high quality and competitiveness.

The biggest challenge facing Ukrainian agriculture at present is logistics. The blockade of maritime routes has made global exports impossible, forcing reliance on road transport, which faces difficulties at borders and delays (Development of viticulture in Odesa region..., 2023). In 2023, the primary suppliers of grape wine to Ukraine were Italy (36.7% of total imports), Spain (16.9%), Georgia (13.7%), France (11.6%), Germany (4.4%), Moldova (3.6%), Portugal (3.1%), and Poland (2.3%) (Official website of the State..., n.d.).

There is a risk that the Ukrainian market will continue to be filled up with imported products. However, given the low purchasing power of the population and military actions within the country, other developments are also possible, including a likely decline in wine consumption, as this beverage is not a necessity (Fig. 6).



Figure 6. Wine Import forecast using exponential smoothing

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Supporting the assertion that Ukraine produces wines that can compete with those from France, Italy, and Spain, and sometimes even surpass them, are expert tastings. "Ukrvinprom" in collaboration with the State Consumer Service, as well as the representatives from the Antimonopoly Committee of Ukraine (AMCU), the State Tax Service (STS), the Ministry of Agrarian Policy, the Ministry of Economy, and the Association of Sommeliers of Ukraine, has repeatedly organised meetings of the tasting commission. At these events, samples of both Ukrainian and imported wines purchased from retail chains in Ukraine are tested. These tasting events are unprecedented for the Ukrainian wine market and hold significant importance for quality control and enhancing the competitiveness of Ukrainian wine products. As the results of the meetings have shown, 30% of imported wine products and 90% of imported wine-based beverages exhibited various violations, unlike the Ukrainian samples. This underscores the importance of such initiatives in ensuring high-quality standards in the Ukrainian wine market and confirms the competitiveness of Ukrainian wines on the global stage (Wine production in Ukraine..., 2023). Currently, Ukraine needs to seek new markets for its products globally, considering that the European wine market is highly competitive, and the significant volumes of supply complicate the entry of Ukrainian producers into it.

The current state of viticulture in Ukraine does not favour the development of local wine production. The

viticulture industry in Ukraine is currently facing several significant issues (Kirillova, 2015). The mismatch between the production volumes of table grapes and the needs of the population, as well as between technical grape varieties and the requirements of wine production, negatively impacts the industry's development. Planting vineyards with lower-quality planting material reduces productivity, while old and sparse plantations increase production costs, lowering its competitiveness. The insufficient number of equipped wineries and storage facilities limits production scale and product quality, while the lack of an adequate logistics system complicates the effective delivery of wine to consumers. Low consumer awareness and the absence of a wine culture restrict demand for Ukrainian wine, and inadequate branding identity and advertising hinder its promotion in the market. Additionally, a significant labour shortage due to the military situation creates further difficulties for enterprises. Despite these challenges, wine production in Ukraine has the potential for development due to its favourable climate and the diversity of grape varieties. Significant government support is needed to address the industry's issues and ensure its sustainable development (Why wine doesn't sparkle, 2023).

To support wine production, the government can implement a range of measures, including introducing effective funding programs and encouraging investment in the sector. The introduction of a favourable tax regime and the simplification of the registration process for wine

production companies are also important. To support the development of wine production, it is necessary to construct modern wineries and storage cellars, as well as improve the logistical infrastructure for the effective supply of wine to consumers. Financial support should focus on these key aspects to ensure stable growth and competitiveness for Ukrainian wine production. To adapt to EU requirements, it is essential to patent new names for borrowed wine and other beverage names (such as champagne, cognac, sherry, and khorosh), and to create a wine cadastre to monitor wine quality (Davydenko, 2023).

It is worth noting that the wines produced in Transcarpathia received an official geographical indication (GI), which enhances their competitiveness in the international market and contributes to the economic potential of the relevant region. The granting of this status by the Public Union "Transcarpathian Grapegrowers and Winemakers" is an important economic event that protects local wines as unique products and promotes them beyond Ukraine's borders. The document was presented to the founder of the union, Hennadiy Hutman, by the First Deputy Director of the Ukrainian National Intellectual Property and Innovation Office, Bohdan Paduchak (Chateau Chizay's official..., n.d.). The GI, analogous to the European PGI system, regulates production practices while maintaining high product quality. This ensures added value for grape products and supports the economic development of the region. The author of this study believes that a similar practice should be applied to other Ukrainian wines.

Regarding investment, despite the martial law, risks in Ukraine are the primary concern for investors in the viticulture and wine production sector. The owner of the wine production company Vinos de La Luz and an investor in Ukrainian wine production, Ricardo Núñez, sees his mission as teaching Ukrainians to drink native wine, which he believes will most significantly contribute to the development of the industry (How to support winemakers..., 2023).

The author of this research believes that it is necessary to raise public awareness about wine, its quality, and value through the organisation of events to promote Ukrainian wine – such as wine festivals, food, cheese, and wine festivals, masterclasses and tastings, and information campaigns (organisational and educational support). There have already been some achievements in this direction, including the initiation of the Day of Odesa Black – a grape variety (Ukrainian wine production should ..., 2023). Wine producers in Ukraine should establish a clear brand identity and develop an effective marketing strategy for promotion. It is important to ensure quality packaging and highlight the product's origin, as this can positively influence consumer perception.

The next issue to consider is the existing support from the government, particularly for enterprises that grow and process grapes. The government has introduced several programs, available through a unified state agricultural register. In 2022, within the framework of the state support program for the development of horticulture, berry farming, and viticulture, financial assistance from the World Bank provided funding amounting to UAH 322 million, which allowed for the creation of approximately 400 permanent and 9,000 seasonal jobs. This support has continued into 2023, with a plan to allocate about UAH

1 billion. As of 4 April 2024, according to the report, UAH 694.2 million has been allocated for the development of horticulture, berry farming, and viticulture (Grants for horticulture..., 2024).

In turn, the Verkhovna Rada of Ukraine has adopted amendments to the legislation that simplifies the registration and operation of the wine production business, including Bill No. 9030 dated 9 August 2023. Accordingly, the adopted Law "On Amendments to the Tax Code of Ukraine and Certain Laws of Ukraine on the Development of Wine Production and Simplification of Economic Activities for Small Wine Producers" No. 3303-IX dated 9 August 2023 (Law of Ukraine No. 3303-IX..., 2023). The main changes in the legislation include several key aspects. Firstly, for small wine producers producing up to 10,000 decalitres per year, the process of obtaining a license has been simplified. They can now apply for a license along with a payment receipt, conduct wholesale trade without a separate license, and carry out retail trade without a retail license. Secondly, tax benefits and simplified reporting have been provided for small producers. The license for wholesale trade now costs 30,000 UAH instead of the previous 500,000 UAH. Reporting is required to be submitted annually rather than monthly as before. Thirdly, there is the possibility of using modern packaging materials, including bottling wine and wine beverages in metal cans and kegs.

These changes are aimed at stimulating the development of small wine production, optimizing the requirements for the material and technical base, simplifying the licensing procedures, and enhancing the competitiveness of Ukrainian wines. Industry associations believe that deregulation will contribute to an increase in the number of winemakers and an expansion of the range of wines in Ukraine (Davydenko, 2023).

The growth in the number of wine production enterprises will increase competition, stimulating the production of new, unique wine blends to satisfy consumer demand. This will foster the development and cultivation of various grape varieties across different regions. The simplification of bureaucratic procedures for obtaining permits, licenses, and certificates generally makes it easier for winemakers to operate.

The draft law "On Grapes and Viticultural Products" (No. 9139), which is preparing for its second reading, includes the unification of terms and definitions, the classification of grape varieties, and requirements for the production of viticultural products (The Parliament adopted..., 2024). It establishes principles for the inspection of wine production, recognition of controlling bodies and their powers, and specifies penalties for violations of the law's requirements. This law introduces definitions of the mechanism for protecting GI within Ukraine. It also envisages the creation of a unified state information system called the "Viticultural and Wine Production Register," supports viticulture and wine production, and introduces new terms and definitions under European standards. Additionally, it anticipates the possibility of state support for viticulture and wine production.

Moreover, there are plans to expand the grape and wine production zones, as theoretically, grapes could be cultivated across a larger part of Ukraine's territory, along with diversification (searching for new recipes and wine

flavours by consumer demand) (Ukrainian wine production should..., 2023). For example, there is a shift in consumer preferences from port wine to youth-oriented drinks based on wine in metal cans. Rosé wines have attracted increased attention globally, particularly associated with the Barbie style, especially following the release of the respective film that became an information catalyst for many producers to present their new wines. This has boosted consumption and attracted new consumers to producers who previously specialised in port wine. The combination of Croft Pink and tonic was a natural fit, as it is a refreshing drink, providing convenience for consumers (single serving). For example, due to its ease of serving, this mix has become popular among airlines (Adrian Bridge..., 2024).

There are already specific regional programs aimed at developing viticulture. In the Odesa region, in particular, the "Agrarian of Odesa" program includes funding the creation of a vineyard cadastre for the region. Recently, approximately 5 million UAH has been allocated from the regional budget for the development of wine production (Winemakers and viticulturists of ..., 2023; Development of viticulture in Odesa region ..., 2023).

With Ukraine achieving candidate country status for EU membership, new prospects have arisen in agriculture, particularly in the viticulture and wine production sectors. The European Parliament has recently decided to abolish the EU import tariff on all Ukrainian exports, which presents a historic opportunity for Ukrainian agriculture, especially viticulture. This decision is particularly significant for regions where viticulture and wine production play an important social role by providing employment (Current issues of viticulture..., 2023; Winemakers and viticulturists of ..., 2023).

The European Union countries are actively assisting Ukraine. In 2023, the USAID program "Competitiveness of the Ukrainian Economy" supported the participation of 10 Ukrainian winemakers in the ProWein exhibition in Düsseldorf, promoting the development of exports under the brand Wines of Ukraine. Ukrainian wines are gaining international recognition thanks to this support (Wines of Ukraine..., 2023).

The renewal of Ukraine's membership in the International Organisation of Vine and Wine (OIV) is also a significant step for Ukrainian viticulture development. This event symbolises the integration of the state into the global community. The OIV, the legal successor to the International Bureau of Vine and Wine, which operated from 1924 to 2001, unites 49 countries and serves as the main organisation that sets wine production standards at a global level. It comprises four committees: viticulture, oenology, economics and law, and health and safety. The organisation includes 85% of the world's experts in the field of wine production and represents the interests of 80% of wine consumers. Ukraine's participation in the OIV provides access to modern knowledge and innovations, which are essential for the development of the national wine industry in the context of European integration. It also creates opportunities for the exchange of experience, which aids in promoting Ukrainian wines in international markets (Rejoining the International Organisation..., 2023). Membership in the OIV opens access for Ukrainian winemakers

to international databases and cutting-edge technologies, contributing to the creation of competitive products and expansion into new markets, including the EU. It also helps to raise production standards in line with European requirements, particularly regarding GI. Membership will enhance awareness of Ukrainian wine and showcase its potential on the world stage. However, dynamic economic changes, war, competition from imported wines, a lack of harmonisation of legislation with EU directives, and a low level of wine consumption culture pose obstacles to the industry's development that must be overcome.

Despite these existing challenges, Ukrainian wine production has significant potential for growth. With 15 natural viticultural macro-zones and 58 micro-zones, Ukraine, with favourable government policies, has every chance of becoming a global leader in wine and wine product production. This is one of the key areas for creating added value, the potential of which the author of this study aims to increase (Discussion of Ukraine's wine..., 2023).

With the development of digitalisation, information about wineries spreads rapidly. The COVID-19 pandemic stimulated interest in local wines, while domestic tourism contributed to their popularity. Successful cases, such as the craft winery Kalyus Winery, demonstrate that most wines are sold during tastings and through Instagram. Since the beginning of 2022, the winery has signed dozens of contracts with restaurants, bars, and wine boutiques. Small wineries like Kalyus Winery also show a social focus in their business, donating 10% of sales to support the army and various projects. For instance, they purchased meat and made canned goods for the military (Wines of Ukraine. Podillia..., 2023).

Another example of craft production that has grown into a larger operation is Beykysh Winery, which opened tasting tours and created a wine club to promote its products. In 2022, plans were underway to open a small hotel to attract tourists and expand the business (Between Barcelona and Ochakiv..., 2021).

The owner of Bohdan's Winery also emphasises the importance of educational work that small wine production enterprises must conduct to attract consumers. He believes that financial assistance from the government and a simplified mechanism for obtaining support from investors are essential for the development of the wine industry in Ukraine (Wines of Ukraine. Podillia..., 2023).

To ensure the effective use of aid from Western countries, it is necessary to develop a clear government program for agricultural development. For the wine production sector's development, it is important to create a special government program aimed at elevating the wine industry to a new level. The program should include the identification of development priorities for viticulture, taking into account regional and zonal characteristics, improving the mechanism for state support for enterprises, individual entrepreneurs, and household farms in the field of viticulture, as well as ensuring the development of wine production.

Measures must also be taken to develop the infrastructure of the wine production market, diversify sales channels, and ensure product quality. This includes regulating supply and demand and protecting the market from low-quality imported products and raw materials. It is vital to increase the capacity of the grape market and its

processed products, considering the population's needs, purchasing power, and export opportunities. Furthermore, collaboration between scientists and practitioners is necessary to improve the quality and recognition of Ukrainian wine products. Finding methods to enhance competitiveness through the implementation of modern technologies and attracting investments in the wine production sector will positively impact the promotion of wine brands, expansion of sales markets, and the formation of a positive image of Ukrainian products.

► Discussion

The article by K. Jesiotr & E. Szymanska (2016) discusses the development of enotourism in Poland, confirming that appropriate promotion is the most significant factor in its success. The authors employed a survey method, the results of which corroborated the initial hypothesis. An important contribution of the work is the recommendations for changes in Poland's wine production legislation, support from local authorities, and measures to promote wine culture. The author concurs with the findings, recognizing the importance of these factors for the development of enotourism in Ukraine as well. It is also worth agreeing with the conclusions of L.M. Sheridan *et al.* (2009) regarding the development of wine tourism and its impact on rural communities, as their ideas are relevant to Ukrainian wine production. The article emphasises the importance of connections between wineries and local communities, which is particularly pertinent for the rural regions of Ukraine, where viticulture and wine production have deep-rooted traditions.

As in the Canary Islands, many wine production regions in Ukraine host small and medium-sized wineries, that are closely linked to local communities. These wineries can be vital sources of employment and stimulate economic activity through participation in cultural events and initiatives that promote the preservation of local traditions and culture.

Given the challenges faced by both Ukrainian wineries and communities, such as generational changes and economic pressure, it is essential to maintain and develop these connections. Strengthening cooperation between wineries and local communities can help preserve local wine production culture, foster sustainable development in rural areas, and bolster economic ties. Thus, Ukrainian wineries can leverage the findings of this research to develop growth strategies that take into account the needs and interests of local communities, thereby ensuring sustainable development and enhancing their competitiveness in the market.

In the context of Ukrainian wine production, it is worth agreeing with the conclusions of G.A. McDermott & R.A. Corredoira (2011) regarding the importance of establishing new public-private institutions to transform the sector. Similar to the Argentine example, the development of the wine production sector in Ukraine could gain significant benefits from close cooperation between public and private organisations. Such collaboration would facilitate the unification of various producer groups that previously operated in isolation or even competed with each other.

The establishment of new institutions that act as "social bridges" and "knowledge bridges" could promote

more effective dissemination of knowledge and resources, which, in turn, would enhance the competitiveness of Ukrainian wineries on the international stage. An approach that combines institutional and network analysis, as demonstrated in the Argentine experience, could be employed to support innovative development strategies in Ukraine, particularly through the development of new products and services and the improvement of management practices.

The findings of J. Simpson (2011) may be beneficial for Ukrainian wine production in several aspects, particularly concerning the organisational structure of the wine production industry and vertical integration. In particular, Simpson notes that the quality of grapes and the nature of market demand significantly influence the structure of wine production enterprises. This can be applied to the Ukrainian context, where the quality of local grapes and market requirements are also critical factors determining the success of wine production enterprises. The experience of New World countries such as Argentina, Australia, and California shows that vertical integration (meaning the combination of grape growing, wine production, and sales within one company) can contribute to the creation of large wine production factories capable of producing branded wines. In Ukraine, this approach could be employed to establish more efficient and competitive wine production enterprises that could better control the quality of their products and more effectively enter international markets. The results of this research correlate with data highlighting the importance of integrated development strategies for enhancing the competitiveness of the Ukrainian wine production sector. Similar to Simpson's studies, the importance of understanding local and international markets for shaping production and marketing strategies in wine production is emphasised.

The findings of M. Thorpe (2009) regarding the globalisation of the wine industry are also relevant to the Ukrainian wine production sector. In particular, Ukraine is part of the global wine market, where competition is increasing among traditional European producers, "New World" producers (such as Chile, Argentina, and Australia), and emerging markets like China. Like China, Ukraine has the potential for increased wine consumption, as well as the opportunity to strengthen its position as a producer in the global market. In the context of globalisation and changing consumer habits, Ukrainian wine production enterprises can benefit from expanding their markets and improving product quality, which will aid in competing with other major producers.

Furthermore, the restructuring and modernisation of the Ukrainian wine industry, as highlighted in the article regarding the Chinese experience, may become a key factor for adapting to changes in the global market and meeting the growing demand for quality wine. Thus, the author agrees that the globalization of the wine industry presents both threats and opportunities for developing countries, including Ukraine.

The article by D. Aylward & M. Clements (2008) examines the strategies employed in the Australian wine industry, particularly in the commodity wine market, and analyses their effectiveness in responding to contemporary challenges and opportunities. Several valuable

lessons can be gleaned for Ukrainian wine production; however, there are also aspects with which one may disagree. It is essential to emphasise the need for product and market differentiation, the creation of regionally identified products, and an understanding of global trends. At the same time, a diverse approach to market price segments should be maintained, rather than limiting oneself solely to the premium segment, to maximise all development opportunities.

Several important lessons from the studies mentioned below can be applied to Ukraine. The integration of wine tourism with the promotion of wine on online platforms, as suggested by V.J.P.D. Martinho (2021), could significantly enhance the recognition of local brands and stimulate demand. The research by G. Chen *et al.* (2022) demonstrates that data analysis from trading platforms enables the examination of consumer preferences, including product characteristics and service quality, which can be utilised to improve the marketing strategies of Ukrainian producers. J. Shen (2019) emphasises that online platforms facilitate price transparency and reduce marketing costs, which is crucial for expanding sales channels in conditions of limited resources. Additionally, employing modern models, as utilised by the authors, such as hedonic regression and machine learning for price prediction, could contribute to a more accurate understanding of market trends and optimise the sales strategy of Ukrainian wine.

► Conclusions

In Ukraine, viticulture continues to face serious challenges that adversely affect production. Since 2014, there has been a reduction of 14,000 hectares in vineyard areas, with total production decreasing by 171,500 tonnes. The main reasons for this are the annexation of the wine production region of Crimea and bureaucratic obstacles that complicated the acquisition of licences until 2018. Despite numerous challenges, Ukrainian wine production has continued to develop, and some positive trends have already emerged, thanks to small producers who may later form the foundation for larger enterprises. There has been a growing interest in local wine, and domestic tourism has contributed to the popularisation of this beverage. The

professional level of grape growers and winemakers has also improved, facilitating the development of the industry.

However, with the onset of the full-scale war in 2022, the wine production sector has suffered significant losses, as a large portion of vineyards have found themselves under occupation or threatened by shelling. Statistical data indicates a decline in grape production from 836,000 tonnes in 1990 to 232,000 tonnes in 2023, particularly due to an 82.4% reduction in the area of productive vineyards since 1990. The market is dominated by technical grape varieties, including Aligoté, Cabernet Sauvignon, and Muscat; however, there is a shortage of table varieties. Overall, viticulture and wine production remain important sectors of the economy, but modernisation of production processes, investment, and government support are necessary for their recovery and development, as existing problems such as the decrease in vineyard areas, an increase in imports, a decline in purchasing power, and a lack of modern infrastructure remain pressing issues.

The practical significance of this work lies in establishing a foundation for strategies and policies aimed at implementing innovations, expanding vineyards, enhancing wine consumption culture, and developing branding and marketing strategies to improve the competitiveness of Ukrainian wines in domestic and international markets. Prospects for further research may include analysing the effectiveness of various models of government support for wine production, exploring opportunities for integrating wine tourism into the overall development strategy of the industry, and assessing the impact of modern technologies on the quality and yield of vineyards.

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► Conflict of interest

None.

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Виноробство в Україні: виклики, можливості сьогодення

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► **Анотація.** Актуальність дослідження зумовлена необхідністю подолання викликів, що стоять перед виноградарством та виноробством України, таких як відсутність послідовної державної політики, високі податкові бар'єри, конкуренція з імпортною продукцією та негативний вплив військових дій, для забезпечення їхнього сталого розвитку та відновлення. Метою дослідження був аналіз сучасних тенденцій у виноградарстві та виноробстві України, визначення основних проблем та розробка пропозицій щодо їх вирішення для стимулювання розвитку галузі в умовах євроінтеграції та воєнного стану. Дослідження зосереджено на оцінці сучасного стану виноградарства та виноробства в Україні з використанням статистичних методів для аналізу виробничих показників та структурних змін у галузі. У ході дослідження було виявлено значне скорочення площ виноградників у плодоносному віці та зниження обсягів виробництва винограду з 1990 по 2023 роки. Було встановлено, що воєнні дії призвели до додаткових втрат виноградників та виноробних потужностей, що негативно вплинуло на розвиток галузі. Також було проаналізовано структурні зміни у виноробній галузі та узагальнено їх наслідки для національної економіки. Незважаючи на труднощі, в 2014-2023 рр. спостерігається зростання інтересу до українського вина на внутрішньому ринку та початок відновлення експорту, що свідчить про потенціал галузі до відновлення та розвитку. Результати роботи можуть бути використані органами державної влади та підприємцями для розробки політики підтримки виноградарства та виноробства, спрямованої на зниження імпоротної залежності та підвищення конкурентоспроможності української винної продукції

► **Ключові слова:** вино; державна підтримка; євроінтеграція; економічні виклики; розвиток галузі; інноваційні технології



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The impact of digital technologies on the effectiveness of management in the agricultural sector of the Kyrgyz Republic

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► **Abstract.** This study aimed to identify current trends in the use of digital technologies in the agricultural sector of the Kyrgyz Republic. It used theoretical approaches to study the global development of digital technologies and empirical methodologies to assess their implementation in Kyrgyz agricultural enterprises. The findings indicated the growing importance of digital agricultural technologies for improving the efficiency of agricultural operations worldwide, including in Kyrgyzstan. This progress increases the ability to more effectively meet consumer demand for the products produced by these enterprises. The integration of technologies such as artificial intelligence, database systems, robotics, smart sensors and automation into the management of Kyrgyzstan's agricultural enterprises is leading to cost optimisation, lower production costs, higher yields and the production of higher quality agricultural goods. Improving management efficiency is a key element of these reforms and is crucial for the successful operation of companies in the sector, especially in light of the current economic conditions. Modern digital technologies significantly increase the efficiency of management in the Kyrgyz agricultural sector by facilitating the rapid collection and processing of data.

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They also expand the possibilities for making the right management decisions, and thus increase the overall efficiency of enterprises in the country's agricultural sector

► **Keywords:** agriculture; innovative approach; administration; economic sector; quality of implementation of solutions; government regulation; management mechanism

► Introduction

Contemporary digitisation tendencies profoundly influence national economies in the context of persistent globalisation. In December 2023, the Ministry of Digital Development of the Kyrgyz Republic and the UN Development Programme proposed strategies to expedite digital advancement across many sectors, including agriculture (Promoting digital transformation..., 2023). The evaluation of Kyrgyzstan's digital readiness revealed consistent utilisation of digital technology and significant advancements in developing robust digital infrastructures for managerial efficacy. This highlights the significance of these solutions for managing agricultural operations and the necessity to analyse essential facets of digitisation in agriculture. Improving digital management is essential for augmenting the overall efficiency of the nation's agriculture sector.

The study by M.O. Amanalieva (2021) examined a broad spectrum of pressing challenges with the development and implementation of digital technological solutions across diverse areas and sectors of the Kyrgyz Republic's national economy. The researcher highlights that the digital economy is a paramount priority in the policy of the Kyrgyz Republic, as demonstrated by the government's adoption of documents outlining its key development prospects. The study indicates that the implementation of digital technological advancements in agriculture will enhance the efficiency of process management and yield measurable outcomes, namely in improving product quality and delivery timelines.

A.B. Karbekova & A.A. Abdykalykova (2023) examined the impact of contemporary technical innovations on enhancing the productivity of agricultural firms in the Kyrgyz Republic. The authors concluded that digital and "smart" technologies, including robotic equipment, unmanned aerial vehicles, high-precision instruments, onboard equipment and sensors, software, local meteorological stations, satellites, and digital data, are extensively utilised in Kyrgyzstan's economic sector, particularly in agriculture, significantly streamlining the management of economic activities.

Therewith, Y. Jiang *et al.* (2024) examined various aspects of the overall factor productivity of agriculture and the development of "digital" villages. According to the researchers, the emergence of technologies that allow the transferring accounting of settlement transactions in agriculture to a digital format opens up new opportunities in the entire field in a complex. There is a direct relationship between the productivity of agricultural production and the use of digital technologies in the agricultural sector.

The problems of strengthening agricultural enterprises through the introduction of modern digital technologies into their activities were discussed by D. Kumar (2024). The author points to the fact that agriculture plays a substantial role in the economy of an agrarian country since it provides a substantial amount of funds to its budget. There-

by, the success of the enterprises of this economic sector largely determines the current indicators of the standard of living in the country, which, in turn, determines the need to increase the efficiency of their activities through the introduction of advanced technological solutions.

Further investigation is necessary on the provision of trained specialists in digital technologies to agricultural firms in the Kyrgyz Republic, to enhance their management and operational efficiency. A comprehensive and systematic analysis of several critical factors for safeguarding corporate data is essential when integrating digital technology in the administration of agricultural firms. The aim of this study was to investigate the potential for optimising management processes within the agriculture sector of the Kyrgyz Republic through technology solutions.

► Materials and methods

This study employs a technique that encompasses both theoretical and empirical analysis of the current challenges associated with the use of contemporary digital technological solutions in the operational activities of firms within the agriculture sector of the Kyrgyz Republic. The theoretical study involved analysing the current state of modern digital technology implementation in the agriculture sector of the Kyrgyz Republic as of 2024 and evaluating the effectiveness of addressing pressing practical challenges in company management within this subject. The process entailed integrating analytical, synthetic, and generalisation methodologies to construct an objective study.

Through the application of the analysis method, the most important areas of application of digital technologies in individual countries were investigated (China and India, selected for analysis as the countries with the largest population in the world, in which agriculture accounts for a substantial part of gross domestic product (GDP) (8.9% and 17%, respectively, as of the beginning of June 2024) and at agricultural enterprises of the Kyrgyz Republic, as of the beginning of 2024, and their potential in the field of building effective management of companies in the agricultural sector of the economies of various states (National Statistical Committee..., 2023; Kumar, 2024; Li & Gao, 2024). The prospects of expanding the range of digital technologies implementation in the management system of the agricultural sector of the Kyrgyz Republic to solve practical problems of increasing the efficiency of agricultural companies were assessed. The evaluation criterion was the comparative performance indicators of the agricultural sector company Limited Liability Company (LLC) Korm-Service, Bishkek before and after the introduction of these technologies.

The synthesis method facilitated the identification of certain digital technologies that effectively operate within the management systems of firms in the agriculture sector of Bishkek and throughout Kyrgyzstan. An evaluation

was conducted regarding the current efficacy of initiatives aimed at integrating such technologies within the agricultural sector of the Kyrgyz Republic, set against the backdrop of the global adoption of digital and other innovative technologies (information and communication) in enterprise management. The generalisation approach was employed to assess the status of digital technology utilisation in the management systems of agricultural firms in the Kyrgyz Republic as of 2024 (National Statistical Committee..., 2023). This was crucial for evaluating the potential to enhance the efficiency of firms in this field, considering the expansion of their management's technical skills.

The research was carried out focussing on Korm-Service LLC, located in Bishkek, which specialises in the selling of animal feed and additives for entities within the Kyrgyz Republic. The empirical study consisted in the introduction of BigData technologies and artificial intelligence systems into the company's activities. In particular, artificial intelligence technologies have been introduced to improve the overall quality of tracking the supply chains of the enterprise's products and sending them to end consumers, which are agricultural enterprises of Kyrgyzstan. An IBM Watson computer system (USA) equipped with artificial intelligence was used to solve this kind of enterprise management task.

Big Data technologies have been implemented to monitor the overall performance of data management. As part of the organisation's activities, an analysis of the practical results from the use of digital technologies in the company's management system was performed and an assessment of the overall effect of the implementation was given, manifested in an overall improvement in the quality of enterprise management in general. In addition, the data obtained allowed for assessing the prospects for further use of technologies of this kind in the management of companies in the agricultural sector of the Kyrgyz Republic.

Big Data digital technologies performed the function of collecting and systematising large amounts of data, including information on various types of feed and feed additives already on the market of agricultural products and entering the market, and data on producers and potential consumers of these products (enterprises of the agricultural sector of the Republic of Kyrgyzstan). In addition, through the use of technologies of this kind, data were collected and analysed on the impact of various types of feed and feed additives on increasing the yield of certain crops, which allowed assessing the feasibility of using certain types of feed and feed additives in the future.

► Results

Every year, there is an ever-deeper integration of digital technological solutions into the agricultural industry. From mobile applications specifically tailored for farm management to robots that completely automate the milking process, as well as unmanned tractors and drones proficient in identifying soil diseases and layer disorders, digital technologies within individual agricultural enterprises, local start-ups, and government agencies provide and actively endorse the implementation of diverse solutions aimed at establishing smart farms and

digital enterprises. As a rule, digital technologies in the management of agricultural organisations are defined as objects of agricultural production, where management systems of this kind, along with Big Data technologies, are widely used as software-controlled systems (Pauschinger & Klauser, 2022).

The extensive implementation of distributed digital data registry technologies by agricultural companies in various countries, including China and India, and particularly in the Kyrgyz Republic (Korm-Service LLC, Bishkek), facilitates comprehensive transaction recording while entirely obviating the necessity for centralised regulatory authorities and databases. In the economic conditions that have formed in the world by 2024, the existing supply chains of agricultural products were created specifically to ensure effective interaction between regional agricultural enterprises and the external agricultural environment. This necessitates the coordination of efficient interaction among all operational components of the current supply chain, encompassing those engaged in the production, processing, and distribution of agricultural products to the final customer. One of the key reasons for the inability to objectively assess the effectiveness of the coordination system of companies in the agricultural sector is the lack of complete transparency in the supply line (Stender *et al.*, 2024). Agricultural enterprises that do not have an adequate level of transparency in the supply and management system risk losing funds, substantially reducing the volume of the customer base, and witnessing a decrease in the value of their own brands. A number of improvements should be made to the general principles of building the supply chain of an agricultural enterprise (Panigrahi *et al.*, 2024) to stimulate increased efficiency and confidence in the trading environment.

As of the beginning of 2024, the expansion of the range of applications of digital technologies to solve the tasks of increasing the efficiency of the agricultural sector in Kyrgyzstan should enable farmers to use modern information platforms and digital innovations for mutually beneficial cooperation of agricultural enterprises within the framework of interaction between the member states of the European-Asian Economic Union. The presence of a favourable market environment will ensure high growth rates of agricultural products, which, in turn, is evidence of an increase in the efficiency of agricultural companies. This will facilitate a smooth and gradual transition from complex and expensive operations to continuously automated processes, which, ultimately, will result in an increase in agricultural production volumes by providing the ability to constantly monitor the entire production cycle. The use of technological solutions of this type provides producers of agricultural and food products with the opportunity to obtain objective data in real-time, affecting a variety of factors that have a direct impact on their productivity. These include: plant health, soil condition, the nature of changes in weather conditions in a certain area, and the presence/absence and nature of exposure to pests and various diseases (Abiri *et al.*, 2023). Table 1 provides data regarding the utilisation of digital technology in the management of firms within the agriculture sector of the Kyrgyz Republic.

Table 1. Distribution of the volume of use of digital technologies by agricultural companies in Kyrgyzstan (number of units)

Region	2017	2018	2019	2020	2021	2022	2023
Kyrgyz Republic	11,863	12,128	12,670	11,478	11,710	11,820	12,014
Batken region	811	613	645	642	658	644	662
Jalal-Abad region	1,210	1,277	1,291	1,258	1,311	1,312	1,355
Issyk-Kul region	711	724	745	738	774	772	780
Naryn region	619	620	622	580	601	598	604
Osh region	1,171	1,168	1,202	1,129	1,186	1,182	1,190
Talas region	414	477	492	445	521	522	530
Chui region	1,640	1,701	1,722	1,556	1,618	1,624	1,633
Bishkek	4,287	4,351	4,761	4,135	3,881	3,875	3,882
Osh	1,201	1,197	1,190	985	1,158	1,291	1,378

Source: compiled by the authors based on National Statistical Committee of the Kyrgyz Republic (2023)

According to Table 1, the largest number of enterprises in the agricultural sector of the economy using the technologies in question in the management system falls on the city of Bishkek. In addition, the leading positions in the country in this area are also occupied by the Chui, Jalal-Abad Regions, and the city of Osh. Low rates of application of these solutions in the management of companies' activities were noted in the Naryn region, where livestock enterprises are mainly concentrated. Expanding the range of applications of digital technologies in the management of companies in this field in

the future will increase their production volumes and achieve higher quality indicators of livestock products. Table 1 shows that the distribution of these technologies in the management of agricultural sector enterprises in the whole country is very uneven, which is evidence of the insufficient development of infrastructure necessary for the introduction of technological solutions of this kind in various regions of the state. Table 2 presents data on key indicators of the use of digital systems in the activities of enterprises in the agricultural sector of the Kyrgyz Republic.

Table 2. Key parameters of the use of digital technologies in the management system of enterprises in the agricultural sector of the Kyrgyz Republic

Parameter	2017	2018	2019	2020	2021	2022	2023
The number of business entities using digital technologies in the management system (units)	185	187	189	165	172	175	182
The number of employees employed in enterprises using digital technologies in the management system (people)	8,352	7,775	7,665	7,287	7,205	7,320	7,622
The total number of specialised professionals of business entities engaged in the maintenance of digital peripherals (people)	155	168	144	145	175	185	196
The amount of the salary fund of business entities using digital peripheral devices in the management system (million soms)	13.2	14.5	14.6	13.8	17.1	17.6	18.4
Production costs of business entities for the introduction, development, and operation of digital technologies in the enterprise management system (million soms)	8.5	6.5	6.2	5.8	5.4	5.5	6.1
The total volume of information and computing services provided, infrastructure design, and software development (million soms)	-	-	0.1	0	0.1	0.1	0.1
The number of web resources owned by enterprises (units)	11	12	9	9	9	10	11
Total number of Internet access points (units)	192	176	201	195	216	215	226

Source: compiled by the authors based on National Statistical Committee of the Kyrgyz Republic (2023)

According to Table 2, the agriculture of the Kyrgyz Republic uses an insufficient amount of computer equipment in business management systems. This means that expanding the range of implementation of these technological solutions in the activities of enterprises in the agricultural sector of the country is a very complex and step-by-step process involving substantial investment of financial resources and high-quality training of specialised professionals in the field of digitalisation who are able to quickly and effectively solve all the tasks assigned to them. It should also consider that the infusion

of financial resources from the state budget of the Kyrgyz Republic requires proper control of the appropriateness of their use by the Government of the country. The introduction of such systems will contribute to improving the rationality and efficiency of the use of all resources, which in the future opens up opportunities for the Kyrgyz Republic to occupy a certain niche in the global agricultural production system, and to better satisfy consumer demand in the food market.

Artificial intelligence systems provided the organisation of supply chain management for the products of

Korm-Service LLC, in particular, the choice of optimal ways of product delivery and distribution to warehouses, and the chain of delivery of feed and feed additives to the end user. An IBM Watson computer system equipped with artificial intelligence was used to solve this kind of

enterprise management task. Table 3 includes data on the results of the implementation of the mentioned digital technologies in the management system of the company Korm-Service LLC (changes in a number of indicators for the period 2020-2023 are presented).

Table 3. The results of the practical use of digital technologies in the management of the activities of the company Korm-Service LLC for the period 2020-2023

Digital technology	The volume of supplies of agricultural products to consumers	Supply chain management	Managing the sequence of trading operations	Automation of technological processes
BigData	Maintaining and accounting for current supply volumes, (improving the quality of accounting by 10-15%)	Accounting for the number of chains and the accuracy of the direction of products along them (increasing the accuracy of accounting by 15-20%)	Accounting for the volume of operations performed and the results achieved (improving the quality and accuracy of accounting by 10-15%)	Accounting for automation systems and facilities (improving the quality of accounting operations by 12-15%)
Artificial intelligence	Ensuring quality control of the supplied products and the timeliness of procurement and supply processes (improving the quality of control operations by 20-25%)	Providing control over the compliance of products supplied to consumers with the requests put forward (increasing the accuracy of operations performed by 30-35%)	Determination of measures to improve the efficiency of concluded trade transactions (increase the overall level of control by 25-30%)	Search for optimal ways to manage the company's activities (optimisation in the range of 40-45%)

Source: compiled by the authors based on the Introduction of digital technologies into agriculture in Kyrgyzstan (2021)

As follows from the data shown in Table 3, the introduction of digital innovations in the organisation and systematisation of the activities of Korm-Service LLC has objectively increased the overall level of all processes that determine the efficiency of the enterprise. Subsequently, this allowed planning the organisation of a fully automated process of accounting for the volumes of products shipped to consumers and supply chain management. In addition, the necessary conditions have been created to expand the range of use of digital technologies in the management of the activities of this enterprise in the agricultural sector, which will ensure objective competitive advantages in the agricultural market and substantially increase the overall level of management of the enterprise.

Rural firms in nations such as China and India exhibit a sluggish adoption of digital technological improvements in agricultural management (Addison *et al.*, 2024). Digital transformation is crucial for optimising agricultural practices and improving managerial capacities. As of early 2024, around 767 million individuals were employed in agriculture worldwide, predominantly in the Asia-Pacific area (Mwangakala *et al.*, 2024). The implementation of digital technologies enhances agricultural productivity, fortifies infrastructure, and broadens market access. Contemporary digital instruments enhance supply chain management, as evidenced by Korm-Service LLC's performance prior to and following the implementation of these technologies. Table 3 indicates that digital solutions improved supply chain management quality by 10-15%, supplier quality control by 20-25%, and product compliance monitoring by 30-35%. Furthermore, the efficiency of trade operations and general management improved by 25-30% and 40-45%, respectively.

The implementation of contemporary digital and information communication technologies, including "smart" and "precision" agriculture, markedly enhances

the efficiency and productivity of agricultural systems, so ensuring their sustainable long-term development (Pidubna *et al.*, 2024). Technologies such as remote sensing, intelligent sensors, Internet of Things devices, and AI-driven algorithms establish new frameworks for agricultural management, improving decision-making processes. These innovations enhance management quality by augmenting yields, preserving soil health, mitigating pests, and facilitating real-time operations (Shahini *et al.*, 2023). The implementation of digital technologies in Kyrgyz agricultural firms is constrained by constraints, including a deficiency of qualified management professionals and specialists proficient in ICT (Kaparbekov *et al.*, 2024). Resolving these challenges through superior training can improve supply chain management, encompassing crop delivery, storage, sorting, packing, and distribution. Minor agricultural firms are integral to this supply chain, rendering the proficient use of digital technology essential for comprehensive efficiency. The influence of digital technology on managerial efficiency within Kyrgyzstan's agriculture industry is seen in the heightened adoption and utilisation of these solutions. This can be accomplished by improving specialised training and broadening the scope of jobs addressed by contemporary technical advancements in the nation's agriculture industry.

The activities of enterprises in the agricultural sector play an extremely important role in the Indian economy. As of the beginning of 2024, almost half of the total available labour force was involved in the country's agriculture. Therewith, agriculture accounts for 18.1% of India's GDP. Over the past few decades, the sectors of production and services to the population have made an increasing contribution to the growth of the country's economy, however, the contribution of the agricultural sector has undergone a substantial drop from more than 50% of GDP in the 1950s to 15% in 2020-2023 (considering the constant

prices of goods and services provided). India has seen steady annual growth in food grain production, while the country is among the main producers of certain agricultural crops, in particular: wheat, rice, legumes, sugar cane, and cotton. In addition, the country is one of the world's largest milk producers and the second-largest producer of vegetables and fruits. Food grain production in India reached a record 323.55 million tonnes during the 2022-23 fiscal year, according to the second preliminary estimate, which was published by the "Department of Agriculture, Cooperation, and Farmer Welfare under the Government of India" (Kumar, 2024).

By the beginning of 2024, India had significantly advanced its agricultural development by shifting the food system paradigm. Although agriculture receives less financial investment than industry and services, digitalisation became essential for improving sector efficiency, which had lagged behind other industries (Kumar, 2024). Previously, priorities included mechanisation, chemical agriculture, and genetic advancements. By 2024, the focus shifted to Agriculture 4.0, incorporating Big Data, robotics, AI, and IoT to enhance operations and the entire food supply chain. Digital technologies played a crucial role in India's agricultural and social development by optimizing resource allocation and increasing production efficiency. They also changed production behaviors and lifestyles, enhancing well-being. For example, digital maps of soil properties enabled optimal sowing and harvesting by considering weather and soil conditions. These maps revealed spatial patterns in soil nutrients (Reddy & Das, 2023), showing that soil data had a greater impact on secondary parameters than climate. From

2021 to 2023, the use of digital technologies in soil analysis allowed better management of sowing and harvesting, boosting soil productivity.

By early 2024, the effectiveness of digitalization of Chinese agriculture will depend heavily on funding for advanced technologies. Remote rural regions face significant financial barriers, limiting farmers' ability to utilise technologies that improve agricultural practices. Since 2016, China has combined digital technology with inclusive finance, formulating a new model of inclusive digital finance (Jiang *et al.*, 2024). The 2021 strategic policy "Developing Inclusive Digital Finance in Rural Areas" aims to enhance inclusive finance, alleviate rural financial exclusion, and improve agricultural productivity (Cao & Wang, 2024). This strategy enhances the convenience, efficiency, adaptability and accessibility of financial services by addressing the last-mile challenges of digitalization of agricultural activities. Digital inclusive finance strengthens rural financial systems and promotes sustainable rural economic growth (Chungfang *et al.*, 2024; Gavkalova *et al.*, 2024).

F. Lee *et al.* (2023) point out that digital technology has markedly improved the efficiency of agriculture in China, primarily due to Taobao, a leading e-commerce platform established in 2003. A multitude of farmers set up stores on Taobao to showcase and sell their products. Villages are classified as "Taobao villages" if the number of Taobao stores exceeds 10% of households and the annual e-commerce transaction volume exceeds 10 million yuan. From 2009 to 2023, the number of Taobao Villages increased from 3 to 8,023, indicating the widespread integration of e-commerce among farmers. Figure 1 shows the expansion of Taobao Villages in China from 2009 to 2023.

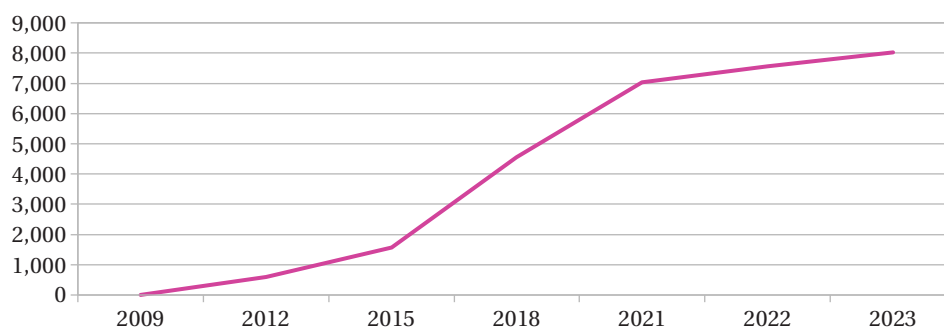


Figure 1. Dynamics of changes in the number of "Taobao villages" in China over the period from 2009 to 2023

Source: compiled by the authors based on data of F. Li *et al.* (2023)

Figure 1 shows a marked increase in the number of Taobao Villages in China from 2009 to 2023, indicating the widespread adoption of digital technology in the agricultural sector. This expansion has led to an improvement in the quality of consumer services and goods. Over the past 15 years, the increasing use of digital solutions shows their popularity and promise. The effectiveness of these technologies depends on the training and technical skills of the staff. In the eastern regions of China, digital technologies are developing most rapidly due to the availability of technology experts and their skilful use by agricultural producers (Li *et al.*, 2023). This emphasises the need to improve staff skills to implement digital management systems in the agricultural sector.

► Discussion

This study revealed the significant impact of new digital technologies in agricultural enterprises globally and inside the Kyrgyz Republic. Information regarding the extent of their integration into the management systems of enterprises in the Kyrgyz Republic, existing challenges in their application, and potential for broadening the utilisation of digital technology advancements was acquired.

In a joint study by H.A. Mwangakala *et al.* (2024), the prospects for using the potential of modern digital technologies in building supply chains for agricultural producers were discussed. Therewith, the authors note that modern digital technologies are very effective in solving the problems of increasing the productivity of agricultural

companies by creating supply chains of products and reducing the cost of delivery to the consumer. According to researchers, this creates optimal conditions for solving problems of food security and the development of agricultural enterprises, through the use of modern digital solutions in their activities. Such an opinion corresponds to the results obtained during the performance of this study since the introduction of technologies of this kind substantially increases the efficiency of agricultural companies, which has been practically proven.

In turn, N.N. Reddy & B.S. Das (2023) considered a number of issues related to the implementation of the latest achievements of digitalisation in agriculture in India. According to the authors, the productivity of traditional agricultural systems can be substantially improved through the use of technologies such as mapping key secondary soil properties using the function of transferring soil data from digitised database archives. However, the effectiveness of the implementation of such technological solutions will be substantially higher if there are highly qualified personnel in agricultural production who are able to quickly adapt these solutions to the real situation in the sector and get the necessary result. The opinion expressed is fully confirmed by the results of the conducted study due to the fact that the effectiveness of the implementation of the solutions in question in the activities of companies in the agricultural sector in the presence of qualified personnel has been practically proven.

E.A. Kitole *et al.* (2024) examined the obstacles associated with the integration of digital technology in the agricultural sectors of several developing nations. They emphasise that without digital breakthroughs, sustaining high production efficiency and cultivating value chains for rural enterprises is exceptionally challenging. The researchers contend that the incorporation of digital technologies in corporate management can substantially increase agricultural productivity and improve the overall appeal of the agriculture industry. The findings align with this study, which illustrates that the successful application and appropriate use of digital technology in contemporary agriculture management enhance production for both individual enterprises and the industry overall.

The advancement of digital technologies in agriculture necessitates specialised training. M. Bampasidou *et al.* (2024) emphasise the difficulties in educating digital specialists for agricultural enterprises, observing that technology innovations have transformed the industry. Superior professional training is crucial for improving the efficacy of agricultural enterprises, particularly in the implementation of more efficient business management methods (Zelisko *et al.*, 2024). This study corroborates their findings, highlighting that enhancing corporate management via digital technology relies on proficient digital experts. G. Sara *et al.* (2024) performed comprehensive research on many digital technologies in agriculture, noting that historical agricultural changes are propelled by contemporary technological advancements. Augmented and virtual reality technologies offer real-time information, allowing farmers to make prompt modifications and efficiently manage their operations (Ismayilzada *et al.*, 2023). Nevertheless, the efficient implementation of augmented reality in agriculture management

necessitates skilled, qualified individuals to proficiently oversee these technologies.

A wide range of problematic issues of regulation by the current legislation of the principles of the introduction of digital data storage systems in the management of agricultural companies was considered in the paper of C. Atik (2023). According to the researcher, the developing agricultural sector of any state inevitably faces the problem of ensuring the necessary level of preservation and protection of personal data. In this context, the adoption of a legislative act within the framework of the existing system regulating the rules for the protection of private data will help streamline the process of expanding the use of digital technological innovations in the agricultural sector and ensure increased efficiency of agricultural management in individual states. The opinion expressed by the researcher seems controversial on the grounds that for the effective introduction of digital technologies into the management of the agricultural sector of the state economy, in addition to the specified legislative act, it is also necessary to introduce a set of measures to comply with current legislation, since otherwise

The study by L. Liu *et al.* (2024) examined the implementation of digital technological innovations in managing the digital finances of firms within the agriculture sector. Researchers assert that quantifying the volume of detrimental emissions from agricultural enterprises into the external environment is a crucial element in managing the operations of entities within the agricultural sector, wherein the implementation of digital accounting systems is significant. Between 2011 and 2019, these systems were empirically evaluated across 30 provinces in China, and the resultant data served as a foundation for the advancement of more sophisticated systems for the digital accounting of harmful emissions and the management of agricultural enterprises in China. The researchers' data and conclusions are corroborated by the results of this study, providing clear evidence of the efficacy of integrating modern digital technologies into the management systems of agricultural enterprises in the state.

H. Wu *et al.* (2023) examined the application of digital technologies to manage harmful emissions in agricultural companies. Several Chinese provinces have effectively implemented digital management systems, improving the efficiency of emission accounting and operational control. These findings are consistent with the results of this study, emphasising that modern digital technologies can solve certain production problems and improve the effectiveness of corporate governance in general. T. Quan *et al.* (2024) studied the impact of innovative technologies on agricultural management, emphasising their contribution to improving economic sustainability and promoting high-quality development. Digital technologies represent effective tools for managing agricultural practices and improving decision-making (Yudina *et al.*, 2024). This paper supports this view by demonstrating that digital technologies improve data storage and quality management, benefiting both individual companies and the agricultural industry as a whole. T. Dibbern *et al.* (2024) highlighted the main drivers and barriers to the adoption of digital technologies in agricultural management. They emphasised the complexity of this transition, noting the importance

of privacy, security and effective data management in the face of external developments. The authors of this study agree, emphasising that the protection of personal data is essential for the effective and secure use of digital technologies in agriculture.

► Conclusions

The impact of digital technologies on the management efficiency of agricultural companies in the Kyrgyz Republic lies in the manifestation of a whole range of new management opportunities for agricultural enterprises through the introduction of these technologies. In particular, the increase in the use of digital database technologies allowed effectively managing large amounts of information, making the necessary management decisions in a timely manner, based on objective and verified data. With regard to the activities of Korm-Service LLC, the introduction of digital database technologies into the company's activities has led to an increase in the quality of accounting for the volume of agricultural products supplied to the end consumer by an average of 10-15% over the period 2020-2023. The number of employees employed in this field increased from 7,287 to 7,622 people over the period 2020-2023 to improve the quality of solving production issues at agricultural enterprises of the Kyrgyz Republic using digital technologies. During the same time period, the number of specialised professionals in enterprises in this field increased from 145 to 196 people.

Therewith, digitalisation processes in the agricultural sector of the Kyrgyz Republic's economy will contribute to the development and improvement of state policy in

related areas, such as information and communication technologies, the manufacture of innovative samples of agricultural machinery, equipment for agricultural work, and optimisation of the use of biological preparations in agriculture, such as fertilisers and minerals. The introduction of these technologies into the management of enterprises in the agricultural sector of the Kyrgyz economy leads to an increase in the efficiency of tracking production and logistics chains, and to the full automation of this process.

The limitations of this study are related to the need to objectively consider the real level of technical training of employees of companies in the agricultural sector, in the management of which modern technological solutions are being introduced. Often, the insufficient level of training of personnel of agricultural enterprises is a serious obstacle to the introduction of technologies of this kind into enterprise management, and this circumstance is very difficult to objectively analyse within the framework of a single study. The prospects for subsequent study in the direction determined by the chosen subject are the possibility of their practical use in the field of management of companies in the agricultural sector of the Republic of Kyrgyzstan, to increase the practical effectiveness of the selected management methods.

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None.

► Conflict of interest

The authors of this study declare no conflict of interest.

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Вплив цифрових технологій на ефективність управління в аграрному секторі Киргизької Республіки

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► **Анотація.** Це дослідження мало на меті визначити сучасні тенденції у використанні цифрових технологій в аграрному секторі Киргизької Республіки. У ньому використовувались теоретичні підходи для вивчення глобального розвитку цифрових технологій та емпіричні методології для оцінки їх впровадження в сільськогосподарських підприємствах Киргизстану. Отримані результати свідчили про зростаюче значення цифрових сільськогосподарських технологій для підвищення ефективності сільськогосподарських операцій у всьому світі, зокрема в Киргизстані. Цей прогрес підвищує здатність більш ефективно задовольняти споживчий попит на продукцію, вироблену цими підприємствами. Інтеграція таких технологій, як штучний інтелект, системи баз даних, робототехніка, інтелектуальні датчики та автоматизація в управління сільськогосподарськими підприємствами Киргизстану призводить до оптимізації витрат, зниження собівартості, підвищення врожайності та виробництва сільськогосподарських товарів вищої якості. Підвищення ефективності управління є ключовим елементом цих реформ і має вирішальне значення для успішного функціонування компаній у цьому секторі, особливо у світлі нинішніх економічних умов. Сучасні цифрові технології значно підвищують ефективність управління в аграрній галузі Киргизстану, сприяючи швидкому збору та обробці даних. Вони також розширюють можливості для прийняття правильних управлінських рішень, а отже, підвищують загальну ефективність підприємств в аграрному секторі країни

► **Ключові слова:** сільське господарство; інноваційний підхід; адміністрування; економічна галузь; якість впровадження рішень; державне регулювання; механізм управління



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Digitalization of control and accounting processes of agricultural enterprises: Risk assessment and management

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► **Abstract.** The digitalization of control and accounting processes is a requirement of the present day due to the wide opportunities to increase competitiveness and efficiency of activities that it provides to enterprises of any industry. The aim of the study was to analyse the effectiveness of digitalization of control and accounting processes to ensure the achievement of the main objectives of agricultural enterprises. The present study used the method of statistical analysis, descriptive and comparative methods, as well as SWOT and PEST-analysis. The study found that the market for software products for agricultural enterprises continues to grow, with a growth rate of 13.5% per year. It was noted that agricultural enterprises can gain significant advantages with the use of new software products, which will increase the speed, accuracy, transparency, and accessibility of control and accounting processes. The paper examined the capabilities of Enterprise Resource Planning systems, which have a wide range of functionality and mostly meet the needs of large agricultural enterprises. The study also covered the consideration of alternative control and accounting tools that may be more suitable for small and medium-sized enterprises due to their simplicity, targeted focus and low implementation costs. Through an assessment of Ukraine's agricultural sector, the paper proves the importance of agriculture for the state, which explains the need for close attention to digitalization processes in the sector. BAS

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AGRO. ERP is considered as an effective system for implementing control and accounting at national agricultural enterprises. As a result of the study, the opportunities and threats, weaknesses and strengths of the digitalization of control and accounting processes in general were noted. It also identified political, economic, social and technological factors that influence these processes in Ukraine

► **Keywords:** agriculture; software products; innovations; Enterprise Resource Planning; financial management; audit

► Introduction

On a global scale, the use of digital products by agricultural enterprises means increasing their ability to meet the more stringent requirements that modern consumers and contractors place on the industry and to meet ever-growing demand. Therefore, the use of certain digital tools to simplify and improve operations is no longer an option, but a requirement for maintaining competitiveness.

The digitalization of control and accounting processes of agricultural enterprises involves the use of certain digital tools to simplify and improve the efficiency of such processes. Big Data (Agostino *et al.*, 2022), Artificial Intelligence (Hasan, 2021), Blockchain (Maiti *et al.*, 2021; Alkan, 2022), Internet of Things (IoT), etc. are actively implemented in the development of such solutions and tools (Kurhan *et al.*, 2023). The software that can be used for these purposes includes various digital platforms, systems (including Enterprise Resource Planning (ERP)), websites, mobile applications, and computer programs (Alam & Hossain, 2021; Gherman *et al.*, 2021). These tools can be involved in planning, optimisation, evaluation, control, monitoring, and other processes, and can also contribute to cost reduction, compliance with legal requirements, and risk management, as noted by M. Bergmann *et al.* (2020) and M.J. Gonçalves *et al.* (2022). In particular, P. Visconti *et al.* (2020), and B. Ramteke & S. Dongre (2022) point out that a single tool can perform both one specific function, such as financial management of an enterprise, and a set of tasks, from accounting to weather forecasting.

Agriculture is one of Ukraine's leading industries and generates a significant share of value added, which in pre-war times exceeded 10% of gross domestic product (GDP) (Semenenko *et al.*, 2021). The war has affected Ukraine's agricultural sector, but agricultural enterprises continue to operate and improve their performance. V. Goi *et al.* (2023) emphasise that the digitalization of control and accounting processes in times of war is of particular importance, as it allows these processes to be implemented remotely and provides access to real-time accounting information from any location. However, this is not the only advantage of digitalization of control and accounting processes, as new technologies can, among other things, increase their speed, accuracy, transparency and efficiency, as noted by I. Lomachynska *et al.* (2023). The analysis shows that the digitalization of control and accounting processes in agricultural enterprises significantly improves their ability to meet modern requirements and meet growing demand. However, further research is needed to fully understand the effectiveness of digitalization in wartime and to identify the most optimal solutions. Therefore, the purpose of this study was to assess the effectiveness of digitalization of control and accounting processes in ensuring the

implementation of the strategic goals of agricultural enterprises. Objectives of the study were outlining the key trends in the market of digital products for the agricultural sector; and describing the use of software solutions to optimise the control and accounting process in Ukraine on the example of BAS AGRO. ERP; conducting a SWOT-analysis and PEST-analysis of the digitalization of control and accounting processes at agricultural enterprises.

► Materials and methods

The study used a comprehensive system of scientific methods that allowed solving the research objectives and, ultimately, achieving its main goal. To describe the key trends in the development of digital products for the agricultural sector, the method of statistical analysis combined with graphical methods was used. This made it possible to assess the current state of the global market for software products for agricultural enterprises, as well as to note the forecast prospects. An indicator that characterises the state of the global market for software products for agricultural enterprises is the size of the market for such software products, expressed in billions of United States dollars (USD). In addition, statistical and graphical methods played a key role in characterising the agricultural sector of Ukraine and other European countries. In particular, their use made it possible to determine Ukraine's place among European countries in terms of the share of value added in agriculture, forestry, and fisheries. For this purpose, the indicators of value added in agriculture, forestry, and fisheries expressed in US dollars and value added in agriculture, forestry, and fisheries expressed as a percentage of GDP were used. The relevant data for the analysis are publicly available on the official website of the Agriculture, forestry, and fishing, value added (current US\$) (n.d.), Agriculture, forestry, and fishing, value added (% of GDP) (n.d.), as well as on the Digital Agro of Ukraine 2024 resource.

The descriptive and comparison methods allowed characterising the capabilities of ERP systems in relation to performing the same actions without implementing ERP. The use of these methods made it possible to describe the main advantages of implementing ERP systems and identify their disadvantages. The identified disadvantages have led to the need to consider and evaluate alternative software products for control and accounting at individual agricultural enterprises. A list of the most popular of these software products is available on the Capterra website (Capterra, n.d.). In the course of reviewing these tools, a comparative analysis was also applied, which allowed us to compare the functions of alternative software products. Among them are Forms On Fire, Granular, Aegro, Kizeo

Forms, Traction, Farmbrite, Agworld, Cropwise Operations, Harvest Profit, EasyKeeper, CropTracker, Conservis, Nax Solutions, fieldmargin, Bushel Farm, OERCA, Farm Service Manager, Work&Track Mobile, AGRIVI, Horse Report System, EasyFarm, MyCrops, TraceX Tech, Blue Skies Accounting, HeavyConnect, +Gestão, Cropolis, Agri360, Farm Matters, EOSDA Crop Monitoring. The descriptive method was additionally used to characterise the features of such a solution as BAS AGRO. ERP, which made it possible to describe the main functions of this system, its cost and suitability for the different needs of agricultural enterprises.

A special place in the study is given to the methods of SWOT-analysis and PEST-analysis. The application of these methods allowed us to summarise and generalise the results obtained using other scientific methods and approaches. Thus, the SWOT-analysis, designed to identify strengths and weaknesses, as well as opportunities and threats of certain phenomena, processes, etc., allowed assessing these aspects in relation to the digitalization of control and accounting processes at agricultural enterprises. PEST-analysis allows for describing the impact of external factors on the activities of the industry as a whole, a particular enterprise, etc. In the context of the study, the PEST-analysis was used to characterise the impact of the

political, economic, social and technological environment on the digitalization of control and accounting processes at agricultural enterprises (on the example of the agricultural sector of Ukraine).

► Results

The global market for digital products for the agricultural sector is actively developing and offering new solutions for agricultural enterprises of all forms of ownership and size. The main technologies involved in this process include artificial intelligence and machine learning, which solve the problem of analysing large amounts of data, as well as the IoT. According to analytical reports, cloud technologies are preferred due to their accessibility, so the share of these technologies, relative to other technologies (local and web-based) will reach 65% over the study period. Comprehensive software solutions for agricultural enterprises, such as ERP systems and other software solutions for managing an agricultural enterprise, are of great importance. In addition to increasing efficiency in the production process, such solutions provide agricultural enterprises with convenient and reliable tools for optimizing control and accounting processes. The market for agricultural software is expected to grow further in the future (Fig. 1).

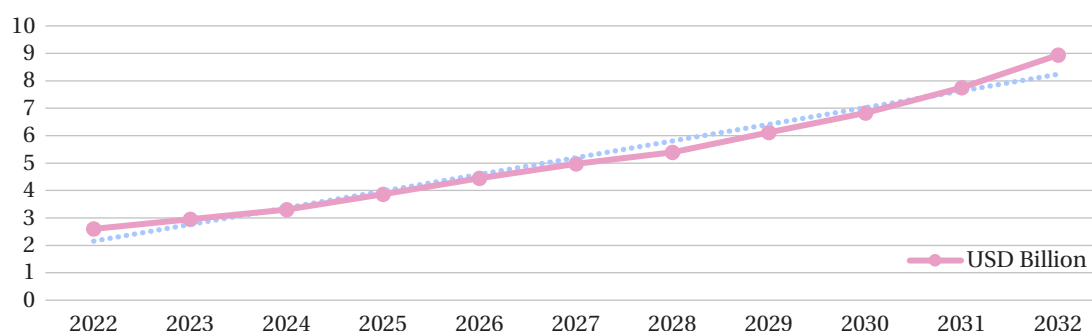


Figure 1. Global market of software products for agricultural enterprises

Source: compiled by the authors

To the data shown in Figure 1, it is worth adding that the market will grow at an average annual rate of 13.5%. The primary driver of growth is the rapid development of technology, but its implementation is not an end in itself, but brings concrete tangible results in the form of simplification and optimization of many processes from finance to production. For example, simplified accounting helps to reduce time and material costs (labour, office space, etc.). Optimisation means more accurate and faster approaches to analysis, evaluation and forecasting, in particular, it improves accuracy in agriculture, providing the basis for more effective decisions to increase yields and maximise profits. At the same time, businesses need to consider potential challenges to technology adoption: high costs, underdeveloped technological infrastructure in rural areas, and a lack of awareness and skills.

Key areas that can be optimised by digital technologies, in particular through the use of specialised applications, encompass: yield monitoring and field inspection,

irrigation, inventory and labour management, field mapping, weather forecasting, and financial management. Often, software providers offer comprehensive solutions, such as ERP systems designed for resource planning and integrating all key business processes into a single ecosystem (Iorgachova & Kovalova, 2023). These systems are able to combine components such as management (personnel, customer, and contractor relations, production, land, inventory, and equipment), data analysis, logistics, and reporting and financial accounting. The latter component deserves special attention in the context of the research topic, so it is advisable to describe in detail the goals of ERP application within this component.

In general, in the context of financial management, ERP systems can optimise the accounting process, improve budgeting, and help to increase the accuracy and minimise errors in reporting. Below is a comparative table of traditional approaches to performing financial transactions and approaches using ERP (Table 1).

Table 1. Comparative table of traditional approaches to financial operations and approaches using ERP

Name of the operation	Traditional design	Execution using ERP
Cost control	Manual data entry, which can increase the risk of errors	Improving input accuracy with automatic recording
Generating reports	Requires a high time investment	Generating accurate reports without time-consuming expenses, access to data at any time
Accounts receivable and payable management	May be accompanied by time delays, tracking issues	Cash flow optimization, automatic notifications
Calculation of profitability	Probability of errors in calculations	Accuracy, support for management decision-making
Risk management	A reactive approach – by determining mistakes that have already been made that can affect efficiency and lead to additional problems	Proactive approach – automatic verification and early detection of inaccuracies

Source: compiled by the authors based on data by J. Schrijvers (n.d.)

Thus, the main advantages of using ERP in the control and accounting process include increased accuracy and transparency, minimization of errors, acceleration of processes, cost reduction, and provision of information for making sound management decisions in a convenient form. At the same time, the implementation of full-fledged ERP systems faces numerous barriers. Firstly, it is worth noting that these systems are more suitable for medium and large agricultural enterprises, given the need to manage complex multi-stage processes. In addition, such enterprises have better financial capabilities and can therefore afford to implement ERP systems, which are expensive. Also, one of the significant barriers is the complexity of implementing ERP systems, which involves the involvement of a third party, high time costs, and the need for extensive training and adaptation of staff. The need to integrate with existing systems and customise them to meet the specific goals of a particular enterprise can also be a significant problem due to a lack of flexibility. At the

same time, it is important to ensure reliable storage and transfer of data in the system, as improper use and configuration can lead to data loss.

As an alternative to complex ERP systems, simpler and less expensive software solutions can be considered. These software products are designed primarily to solve specific tasks, but can also be comprehensive. As a rule, these solutions have a narrower functionality, in particular, for analysing and reporting, but they can fully meet the needs of individual enterprises, especially small and medium-sized ones. The main advantages of such tools include ease of use, focus on specific tasks and goals, low cost, ease, and speed of implementation, greater flexibility and, as a rule, no need for integration with other systems.

Table 2 shows a list of popular software solutions for solving certain tasks of agricultural enterprises, in particular, for optimising control and accounting processes. These are the top 30 most popular applications with a rating of at least 4.5 according to Capterra (n.d.).

Table 2. Comparison of the functionality of popular software solutions for managing an agricultural enterprise

Programme	Forms On Fire	Granular	Aegro	Kizeo Forms	Traction	Farmbrite
Rating	4.7	4.7	4.5	4.6	4.9	4.8
Built-in Accounting	—	Yes	—	—	Yes	Yes
Financial management	—	—	Yes	—	Yes	Yes
Production tracking	Yes	Yes	Yes	Yes	Yes	Yes
Crop/livestock management	Yes	Yes	YesWw	Yes	Yes	Yes
Inventory management	Yes	Yes	Yes	Yes	Yes	Yes
Traceability	Yes	Yes	—	Yes	Yes	Yes
Field mapping	Yes	Yes	Yes	Yes	Yes	Yes
Labour management	Yes	Yes	Yes	Yes	Yes	Yes
Weather records	Yes	—	—	—	—	Yes
Programme	Agworld	Cropwise Operations	Harvest Profit	EasyKeeper	CropTracker	Conservis
Rating	4.5	4.5	4.8	5	4.5	4.5
Built-in Accounting	Yes	—	—	—	—	Yes
Financial management	Yes	—	—	—	—	Yes
Production tracking	Yes	—	Yes	Yes	Yes	Yes

Table 2, Continued

Crop/livestock management	Yes	Yes	Yes	Yes	Yes	Yes
Inventory management	Yes	—	—	—	Yes	Yes
Traceability	Yes	Yes	—	Yes	Yes	Yes
Field mapping	Yes	—	—	—	Yes	Yes
Labour management	Yes	Yes	—	—	Yes	Yes
Weather records	Yes	—	—	—	Yes	Yes
Programme	Nax Solutions	fieldmargin	Bushel Farm	OERCA	Farm Service Manager	Work&Track Mobile
Rating	4.5	4.9	4.8	4.5	4.8	4.6
Built-in Accounting	—	—	—	—	—	—
Financial management	—	—	Yes	—	—	—
Production tracking	Yes	Yes	Yes	—	Yes	—
Crop/livestock management	Yes	Yes	Yes	—	—	—
Inventory management	Yes	—	Yes	Yes	Yes	—
Traceability	—	Yes	Yes	—	Yes	—
Field mapping	Yes	Yes	Yes	—	—	Yes
Labour management	—	Yes	Yes	—	Yes	—
Weather records	Yes	Yes	Yes	Yes	—	—
Programme	AGRIVI	Horse Report System	EasyFarm	MyCrops	TraceX Tech	Blue Skies Accounting
Rating	4.7	5	4.6	5	5	4.8
Built-in Accounting	Yes	—	Yes	Yes	—	Yes
Financial management	Yes	—	—	Yes	—	—
Production tracking	Yes	—	Yes	Yes	—	—
Crop/livestock management	—	Yes	Yes	Yes	—	Yes
Inventory management	Yes	Yes	Yes	Yes	Yes	—
Traceability	Yes	—	Yes	Yes	—	—
Field mapping	Yes	—	—	Yes	—	—
Labour management	Yes	—	Yes	Yes	—	Yes
Weather records	Yes	—	Yes	—	—	—
Programme	Heavy Connect	+Gestão	Cropolis	Agri360	Farm Matters	EOSDA Crop Monitoring
Rating	5	4.6	5	5	4.8	5
Built-in Accounting	—	Yes	Yes	—	—	—
Financial management	—	Yes	—	—	—	—
Production tracking	—	Yes	Yes	Yes	—	—
Crop/livestock management	—	Yes	Yes	Yes	Yes	Yes
Inventory management	—	Yes	Yes	Yes	Yes	—
Traceability	Yes	Yes	Yes	Yes	Yes	—
Field mapping	—	Yes	—	—	—	Yes
Labour management	Yes	—	—	Yes	—	—
Weather records	—	—	—	—	—	Yes

Source: compiled by the authors

As can be seen from Table 2, most of the proposed software solutions are capable of performing more than one task in the field of agricultural enterprise management. These solutions take advantage of the advances in Big Data, Blockchain IoT, Artificial Intelligence and other modern technologies. Many of these applications can solve the tasks of reporting and financial management. At the same time, the cost of using software products is minimal, for example, Farmbrite, which can perform all the

tasks listed in the table, costs USD 39 per month with the possibility of free use during a certain trial period.

Optimization of processes in Ukraine's agricultural sector is critical for the country's economy as a whole, as agriculture is becoming one of the priority sectors of the economy for developing countries. Comparing the results of Ukraine and other European countries in terms of value added in agriculture, forestry and fisheries, it is worth noting that Ukraine ranks sixth in Europe by this indicator (Fig. 2).

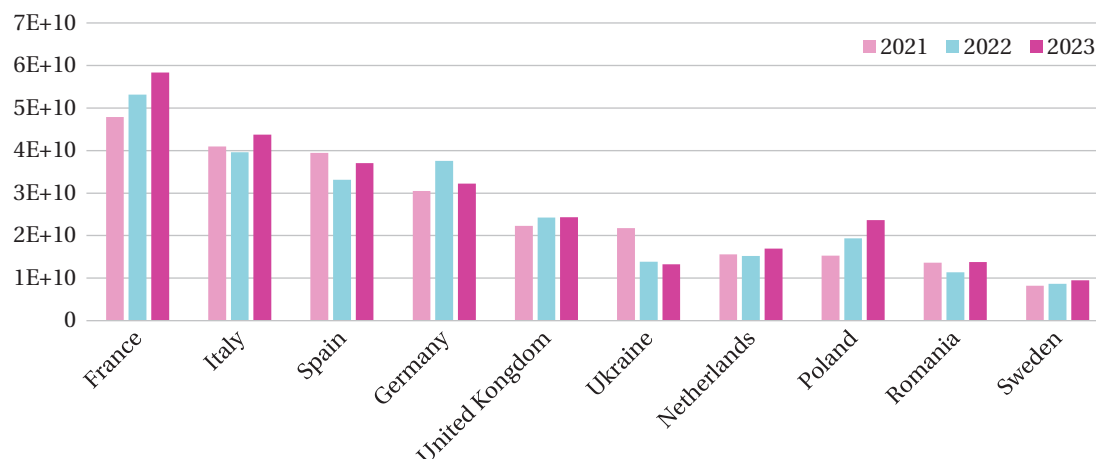


Figure 2. Value added in agriculture, forestry, and fisheries (USD)

Source: compiled by the authors based on the Agriculture, forestry, and fishing, value added (current US\$) (n.d.)

As can be seen in Figure 2, over the last three years (2021-2023), Ukraine's score was highest in 2021 and almost reached the level of the UK. However, the war in Ukraine has had a significant impact on the agricultural sector, and in 2022-2023, the indicator dropped significantly. Thus, in 2021, the value added was more than

USD 21.7 billion, in 2022 – about USD 13.89 billion, and in 2023 – about USD 13.24 billion.

When examining the value added in agriculture, forestry, and fisheries as a percentage of GDP, it should be noted that Ukraine ranks second among European countries (Fig. 3).

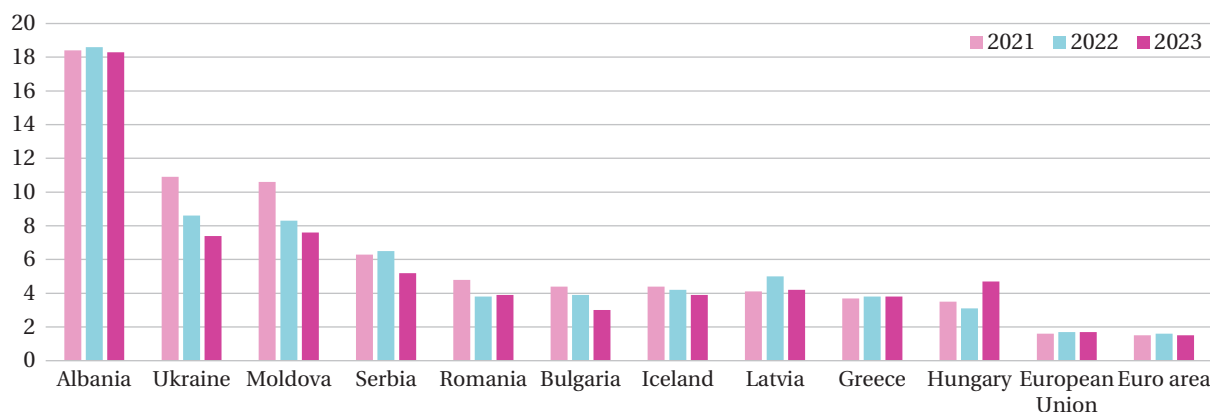


Figure 3. Value added in agriculture, forestry, and fisheries (% of GDP)

Source: compiled by the authors based on the Agriculture, forestry, and fishing, value added (% of GDP) (n.d.)

Figure 3 shows that the value added in agriculture, forestry, and fisheries as a percentage of Ukraine's GDP declined by about 3.5 per cent over the three years under review. However, it is still significantly higher than the European average and the European Union average, which are 1.5 and 1.7 per cent, respectively. The above data confirms the importance of Ukrainian agriculture not only for the country itself, but also for ensuring food security in Europe and the world as a whole. Therefore, the issue of increasing efficiency in the agricultural sector should be high on the agenda of Ukraine and its partners. Digitalization plays a pivotal role in this process.

Increasing the competitiveness of the industry relies heavily on the introduction of innovative technologies, both in the production process (e.g., the use of the latest systems to track fertiliser application levels) and in the optimization of other areas of activity (e.g., accounting automation). Among the most popular innovations in the agricultural sector in Ukraine are autopilots, sectional nozzle

shutdown technologies for protection, drone application and telematics. More than half of innovative agricultural enterprises also use online document management, and about 40 per cent use outdated accounting software (or similar). Only about 19 per cent of agricultural enterprises use software solutions such as those described in Table 2.

Application of software solutions to optimise the control and accounting process in Ukraine on the example of BAS AGRO. ERP. Given the importance of agriculture for Ukraine and the large number of large and medium-sized agricultural enterprises, it is advisable to consider in more detail the possibilities of implementing ERP systems at such enterprises. As noted above, such systems are complex and integrate numerous tasks into a single ecosystem. An important component of such systems is analytics and reporting modules. One of the most popular in Ukraine is the BAS AGRO. ERP system, which contains a powerful arsenal for controlling and accounting for the financial and economic activities of agricultural enterprises.

BAS AGRO. ERP provides opportunities for automating all types of accounting at agricultural enterprises, as well as for planning and optimising business processes. This solution meets the needs of large and medium-sized agricultural enterprises. The main functions of the system include: automation of business processes; business planning; budgeting; determination of material requirements; detailed operational accounting; automation of accounting (land and settlements, services and works, expenses); analysis and planning of divisions; cost analysis, etc.

The cost of BAS AGRO. ERP costs UAH 259,200, but there are also some industry-specific solutions available. For example, the cost of "BAS AGRO. Integrated Enterprise Management. Crop production" equals UAH 39,000. There are also solutions for the livestock industry, as well as separate offers for grain storage facilities, mills, and feed mills. A separate solution, "BAS AGRO. Accounting", costs UAH 14,440. The example of BAS AGRO shows that solutions for the digitalization of agricultural enterprises in general and control and accounting processes in par-

ticular can be very flexible and adapt to the specific capabilities and needs of enterprises. The main task of managers before making a decision to implement a particular system or software product is to define clear goals and the future implementation process, taking into account the needs and problems that may arise in this process.

The evaluation of the effectiveness of digitalization of control and accounting processes in ensuring the implementation of strategic goals of agrarian enterprises by means of SWOT-analysis and PEST-analysis. The assessment of the effectiveness of digitalization of control and accounting processes in ensuring the implementation of strategic goals of agricultural enterprises was carried out by conducting a SWOT-analysis. This allowed characterizing the strengths and weaknesses of the introduction of digital technologies, as well as the relevant opportunities and threats. The results of the analysis are general, i.e., they adequately describe the aspects of digitalization of control and accounting processes in the agricultural sector both in Ukraine and in other countries (Table 3).

Table 3. SWOT-analysis of digitalization of control and accounting processes in ensuring the implementation of strategic goals of agricultural enterprises in Ukraine and other countries

Strengths	Weaknesses
Optimization of control and accounting processes by speeding them up, increasing accuracy, saving resources, and minimising errors. Real-time access to data and monitoring, which allows for timely management decisions Greater control capabilities by tracking transactions, activities, and products. Reduced labour and office costs. Promotion of digitalization by the state.	Depending on the software product chosen, there may be high upfront costs for implementation, training, and integration. Insufficient funding. Lack of highly skilled workers with relevant knowledge in agriculture and information technology. The need to ensure the security of data and information due to the possibility of data leakage or hacker attacks. Underdeveloped technological infrastructure, especially in remote areas.
Opportunities	Threats
Thanks to the automation of a number of routine tasks, employees of agricultural enterprises can have additional time to solve more important tasks. The ability to work remotely can solve problems related to quarantine restrictions, military operations, and other negative phenomena. The use of systems such as ERP allows for greater opportunities for integration with new technologies that provide additional benefits to businesses, ensuring high competitiveness and innovation. In particular, blockchain can increase transparency of operations, and the IoT can be used to optimise resource management. Accurate reporting and real-time access to information enables better risk management. The use of digital tools allows adapting more efficiently and quickly to changes in the legal framework and the market.	Economic instability, the presence of political and/or military conflicts in the country may slow down the digitalization process and reduce the investment attractiveness of agricultural enterprises. The need to meet the demands of rapidly evolving technology and competition can affect the performance of less resilient businesses. Cybersecurity breaches, which can lead to data leaks and significant material losses, as well as damage to reputation and customer confidence.

Source: compiled by the authors

The SWOT-analysis suggests that digitalization itself is mostly beneficial, except for the risk of cyberattacks. Most of the factors identified as weaknesses and threats to digitalization are related to insufficient capabilities of the enterprises themselves or the environment in which they operate. Regarding the environment, it is relevant to note that the state plays a leading role in the digitalization process, providing appropriate legislative and financial support, promoting infrastructure development and improving educational programmes in the field of information

and communication technologies. A general assessment of the environment should be carried out using a PEST-analysis, which will allow describing the political, economic, social and technological factors influencing the digitalization of control and accounting processes at agricultural enterprises. In the context of the study, this type of analysis covers a narrower scale than the SWOT-analysis, the results of which are suitable for many countries. In turn, the PEST-analysis focuses on Ukrainian conditions in order to take into account national peculiarities (Table 4).

Table 4. PEST-analysis of digitalization of control and accounting processes in ensuring the implementation of strategic goals of agricultural enterprises in Ukraine

Political factors	Economic factors
The government's efforts to ensure digitalization in various areas are increasing, providing financial and legislative support for this process. Given the rapid development of technology, regulations may not take into account certain aspects of regulation or may lag significantly behind changes in the technological environment. European integration processes in Ukraine, on the one hand, increase the burden on the political, economic, and other activities in the country due to the need to meet new standards and high requirements. On the other hand, this stimulates the introduction of the latest technologies, which contributes to improving product quality and raising living standards in general. Moreover, Ukraine and individual enterprises have the opportunity to access financing and grants, as well as to exchange experience with advanced countries. The war in Ukraine has significantly slowed down the process of digitalization and affected the investment attractiveness of businesses, especially those located in the areas of hostilities. The recovery from the war, which is still taking place in the country, may be lengthy.	Economic instability caused by the war and other factors is impeding access to financial resources. The investment climate in Ukraine has also been severely affected by the war, which is depriving the country and its agricultural enterprises of additional opportunities for development. Sustainable economic development cannot be imagined without technological innovations, so the digitalization of control and accounting processes is in line with the Sustainable Development Goals, such as Sustainable Development Goal 9 – industry, innovation and infrastructure, and Goal 8 – decent work and economic growth.
Social factors	Technological factors
Ukraine has a strong potential in terms of the number and qualifications of information and communications professionals. However, many workers are moving abroad, including due to the war, so the lack of qualified personnel may affect the efficiency of digitalization processes. The development of technology can lead to a reduction in the number of jobs due to automation, so professionals in the sector need to make efforts to develop new skills. The perception of innovations plays an important role, as the resistance of employees to change can be an obstacle to an effective digitalization process.	Rapid technological development makes digitalization not an option but an objective necessity. The availability of adequate technological infrastructure, such as Internet access, is critical. Such infrastructure may be underdeveloped in Ukraine, especially in remote areas. The agricultural sector is quite receptive to innovations to improve yields, determine fertiliser levels, etc., which provides fertile ground for their introduction into all areas of agricultural business.

Source: created by the authors

In conformity with the results of the PEST-analysis, Ukraine currently lacks the capacity to successfully implement the digitalization process, primarily due to the war. However, even in difficult circumstances, the digitalization process cannot be completely stopped. It is now necessary to intensify work on legislative support for the digitalization process, creating favourable conditions for Ukrainian specialists in the field of information and communication technologies, expanding access to the Internet, developing digital literacy of Ukrainians, etc.

► Discussion

The study fills the identified gaps in scientific works on the digitalization of control and accounting processes at agricultural enterprises. In particular, the study identified not only the advantages and opportunities, but also the risks, threats, and weaknesses of the digitalization of control and accounting processes. These barriers and shortcomings relate primarily to the limited capabilities of agricultural enterprises (financial, human, etc.) and the limitations of the operating environment (underdeveloped infrastructure, legislative framework, etc.). The study focused not only on digitalization at large and medium-sized agricultural enterprises, but also sought to assess digital solutions for small businesses. The

solutions considered in the study are comprehensive and use a wide range of new technologies, including Artificial Intelligence, Big Data, Blockchain IoT, etc.

In order to maximise the disclosure of all the above aspects, the article outlines the main trends in the market of digital products for agricultural enterprises, reveals the advantages of ERP systems and alternative software solutions for control and accounting, provides an assessment of the agricultural sector of Ukraine, and conducts a SWOT-analysis and PEST-analysis of the digitalization of control and accounting processes at agricultural enterprises. The results obtained should be compared with the conclusions of scientists to define potential opportunities for improvement and further research.

The optimisation of control and accounting processes at agricultural enterprises is an essential topic in recent research by Ukrainian scientists (Dubiniina *et al.*, 2022; Potryvaieva & Palieiev, 2023; Verbiivska *et al.*, 2023). The author of this study took into account the results of the work of S. Ihnatenko & I. Tomashuk (2024), who outlined the functionality of popular technologies and information systems used in the agricultural sector today. Similarly to M. Petchenko *et al.* (2023), the researchers identified the most influential trends in digitalization and automation, which include the integration of

ERP systems, accounting automation, and the use of the IoT, Big Data, and analytics. The researchers identify the key benefits of digitalization in the accounting of agricultural enterprises, including improved management, increased productivity, and reduced costs and risks. At the same time, the problems of implementing digital technologies in the field of research are not sufficiently addressed in the work of scientists. S. Ihnatenko & I. Tomashuk limit themselves to remarks on high initial costs, the need for staff training and problems with the integration of new technologies. In the author's opinion, in the course of studying the digitalization of control and accounting processes at an agricultural enterprise, it is advisable to pay more attention to the advantages and opportunities, as well as the problems and risks of this phenomenon.

The work of I. Shepel (2023), which the author relied on in the course of his own research, reveals the capabilities of the ERP system for agricultural enterprises BAS AGRO. ERP. This paper contains an in-depth assessment of this system, including a detailed description of various variations and modules of the system. At the same time, the paper does not consider alternatives to the BAS AGRO. ERP, which leaves out the digitalization of control and accounting processes at small enterprises. T. Hnatieva *et al.* (2023) devoted their work to a detailed assessment of the capabilities of artificial intelligence when used by agricultural enterprises. In the field of control and accounting, artificial intelligence can be used to automate cost accounting, monitor financial status, calculate taxes, manage payments, analyse financial indicators, automate accounting of operations, reporting and auditing, etc. (Novykova *et al.*, 2023). The present study focuses exclusively on aspects of artificial intelligence, but it is not the only technology that can benefit the optimization of control and accounting processes at an agricultural enterprise. Therefore, in the context of the topic of this study, it is advisable to consider solutions that also use Big Data, Blockchain IoT, etc.

Many works by researchers from other countries also note the wide potential of modern technologies to improve control and accounting, such as automation capabilities (Syrtseva *et al.*, 2021; Stender *et al.*, 2024). Particular attention is paid to blockchain technology in the works of M. Bellucci *et al.* (2022), T. Garanina *et al.* (2022), E. Pimentel & E. Boulianne (2020). Scientists concentrate on the practical aspects of the technology and highlight its advantages over traditional approaches. R. Spanò *et al.* (2020) and O. Desplebin *et al.* (2021), also focusing on blockchain, address the future prospects of its use, in particular, in combination with other technologies (e.g., virtual reality). The possibilities of the blockchain in combination with the potential of artificial intelligence are revealed in the works by Y. Zhang *et al.* (2020), A. Qasim & F.F. Kharbat (2020) and H. Han *et al.* (2023). Among other things, scientists study the impact of these technologies on the accounting profession and note the need to change approaches to training professionals. H. Damerji & A. Salimi (2021) linked the effectiveness of the introduction of artificial intelligence technology in accounting to the peculiarities of the perception of new technologies. E. Martaseli & M. Maragita (2023), O.H. Cho (2024) and

C. Estep *et al.* (2024) assess the impact of artificial intelligence on the accounting industry. In general, scientists conclude that the new technology can maximise the efficiency of accounting, but note certain barriers to its implementation, in particular, lack of knowledge (Oklander *et al.*, 2024). G. Rocha *et al.* (2021) noted the broad prospects for the use of blockchain technologies in agricultural enterprises. The researchers noted the use of blockchain by agribusinesses, among other things, for financial purposes. M. Lei *et al.* (2022) focus on the possibilities of tracking agricultural products provided by the blockchain and offer their own view on solving existing problems. A. Rață *et al.* (2022) proposed a framework that combines blockchain capabilities with digital signatures and artificial intelligence to optimise accounting and auditing at agricultural enterprises. The researchers point out that this approach allows for more transparent auditing and accounting through secure transaction documentation, asset control, and product tracking. In addition, the researchers revealed how artificial intelligence can help automate routine audit activities, speeding up the process and minimizing possible manual errors. The researchers do not ignore the possible problems of introducing new technologies (the possibility of bias, high implementation costs, and regulatory requirements). In contrast to these studies, the author's work notes the capabilities of individual technologies rather briefly, as the focus is on integrated software solutions that operate on the basis of one or more of these technologies.

The benefits of using software platforms, individual software tools or a combination of them are outlined in the works by M. Bradford *et al.* (2020), M.M. Thottoli *et al.* (2022) and C. Zhang *et al.* (2022). The main benefits include increased efficiency, reduced time spent on routine tasks, and improved information quality. In the studies by J. Mökander *et al.* (2021) and T.P. Nugrahanti & A.S. Pratiwi (2023), the authors additionally highlight how such solutions can address ethical issues and ensure compliance with standards in the accounting profession.

V. Saiz-Rubio & F. Rovira-Más (2020) investigated the possibilities of the latest software solutions to increase efficiency in the agricultural sector. As in the author's work, the researchers focus on outlining the capabilities of software products to improve the performance of agricultural enterprises, in particular, in the area of control and accounting. This inspired the author to consider more recent ratings of software products for the agricultural sector, which allowed us to provide a list and describe the main functionality of the tools that are most popular today. In addition, the researchers note that the beginning of the 21st century is a very favourable period for the digital transformation of the agricultural sector and the transition to Agriculture 5.0. In this context, the paper notes that the transition to Agriculture 5.0 is a priority for large agricultural producers. Agreeing with the above, it is worth adding that digitalization, as the author of this paper has shown, does not bypass small agricultural enterprises. Due to their flexibility and adaptability, small enterprises are one of the important drivers of digitalization and economic growth (Trusova *et al.*, 2020; Dovgal *et al.*, 2024). Therefore, the inclusion of aspects related to small businesses is a crucial focus of the author's article.

S.A. Shukor *et al.* (2020) do not ignore small and medium-sized enterprises in the context of studying digitalization in the agricultural sector. The authors examine the process of digitalization of the agricultural sector in Malaysia, with a focus on the use and adaptation of ERP systems. The researchers, like the author of this article, discuss the problems of implementing ERP systems at small and medium-sized businesses. However, the works differ in that S.A. Shukor *et al.* (2020) propose an approach to the adaptation of ERP systems by small and medium-sized agricultural enterprises, while the author's work contains alternatives that can be used by such enterprises to replace ERP. A similar approach is considered in the work by V.S. Han *et al.* (2020). The researchers noted that complex ERP systems such as SAP and ORACLE may not be an appropriate solution for SMEs due to their cost, resource requirements, and technical expertise. Instead, SMEs may consider implementing certain local platforms that are open-source and free of charge. At the same time, the solution considered in the study also contains several modules that provide a comprehensive solution for solving various business tasks, including financial management. T. Krassowska *et al.* (2022), also focusing on small and medium-sized enterprises, propose an approach to the selection by such business units of a system for finance and accounting that is appropriate to their tasks. The advantage of this work is the development of a special ranking procedure that makes it possible to model the decision-making situation, on the basis of which managers receive a solid basis for choosing a particular system. E. Trichkova-Kashamova & E. Paunova-Hubanova (2021) presented their own approach to the selection of farm management software, in which the researchers analyse 8 such platforms according to 12 main functions. As in the author's work, the approach takes into account the rating of software users, but contains more specific guidelines for choosing a particular program.

Despite the fact that the author's research focuses on control and accounting in the agricultural sector, it highlights the benefits of an integrated approach. This approach emphasises the importance of integrating digital solutions in the field of control and accounting with other areas of agricultural enterprises' activities. This opinion is supported by the work of J. Munz *et al.* (2020), who studied the process of digitalization in German agricultural enterprises. The researchers focused on answering the question of which functions of agricultural enterprise management information systems are most often used in Germany. The researchers found that most farmers use such systems to maintain documentation, as well as to plan and monitor management processes at agricultural enterprises. A smaller proportion of enterprises use a wider range of digitalization tools, combining software with sensors, hardware, etc. (Sokil *et al.*, 2020). Scientists are confident that understanding digitalization as a simple increase in the use of desktop applications is not yet a transition to smart agriculture. They emphasise the importance of using universal data standards and see an increase in the efficiency of the agricultural sector in moving away from individual applications in favour of developing integrated systems of related products. This

approach may be useful for solving the problem of the need to integrate software products noted in the author's work.

Comparison of the author's work with the conclusions of other researchers allowed confirming the validity of the research results, and identifying its advantages and unexplored aspects. This makes it possible to suggest areas for further research, in particular, a critical area for further work should be the formation of a multi-criteria approach to the selection of a software solution on the example of a particular agricultural enterprise, taking into account internal and external factors of activity. Moreover, some works (Poppe *et al.*, 2023) note the direction of using digitalization in control and accounting processes, which is not disclosed in the article, namely the collection of data for external reporting on sustainable development. In the context of growing concerns about balancing the economic, social and environmental needs of society, this area may be quite relevant for further research.

► Conclusions

The digitalization of control and accounting processes at agricultural enterprises contributes to increasing the accuracy, transparency, speed, and overall efficiency of such processes. The analysis conducted in this study shows that the market for software products for agricultural enterprises has broad prospects. The growth rate of this sector is 13.5% per annum, and the main trends are the introduction of technologies based on artificial intelligence and machine learning for analysing big data, as well as the IoT.

The paper notes that ERP systems can improve the accuracy of input through automatic recording, generate more accurate and timely reporting, optimise cash flow, provide more thorough support for management decisions, and identify problems in advance. At the same time, alternative software products that are simpler and more affordable than complex ERP systems may be a more appropriate solution for small and medium-sized enterprises. These include Forms on Fire, Granular, Aegro, Kizeo Forms, Traction, etc. For Ukraine, the agricultural sector is an important element of the economy, with a value added of more than 7% of GDP even in wartime.

The SWOT-analysis summarised numerous opportunities and benefits of digitalization in the control and accounting activities of agricultural enterprises. At the same time, the results of the analysis made it possible to determine that the main threats and weaknesses of the digitalization process are mainly related to the limited capabilities of the enterprises themselves and their operating environment. The PEST-analysis made it possible to emphasise that the main problems associated with the introduction of digitalization in the control and accounting processes of agricultural enterprises in Ukraine are related to military restrictions and risks, as well as imperfect legislative framework and insufficient infrastructure development in certain regions. The limitation of the study is that the data of Ukrainian agricultural enterprises in general were used for the analysis. This allowed us to expand our coverage, but an analysis of the digitalization of control and accounting processes at a particular enterprise could reveal more specific problems and benefits.

A promising area for further research is the development of a multi-criteria approach to the selection of

digital tools for an agricultural enterprise, taking into account the impact of internal and external factors, as well as the analysis of digitalization opportunities for collecting data for sustainable development reporting in Ukraine.

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None.

►Conflict of interest

The authors of this study declare no conflict of interest.

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Цифровізація контрольно-облікових процесів аграрних підприємств: оцінка та управління ризиками

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► **Анотація.** Цифровізація контрольно-облікових процесів є вимогою сьогодення через широкі можливості із підвищення конкурентоспроможності та ефективності діяльності, які вона надає підприємствам будь-якої галузі. Метою роботи був аналіз ефективності цифровізації контрольно-облікових процесів для забезпечення досягнення основних цілей діяльності підприємств сфери сільського господарства. В роботі застосовано метод статистичного аналізу, описовий та порівняльний методи, а також методи SWOT- та PEST-аналізу. В результаті проведеного дослідження було виявлено, що ринок програмних продуктів для аграрних підприємств продовжує зростати, при чому темп зростання становить 13,5 % на рік. Зазначено, що аграрні підприємства можуть отримати суттєві переваги із застосуванням нових програмних продуктів, що дозволить збільшити швидкість, точність, прозорість та доступність контрольно-облікових процесів. У роботі розглянуто можливості систем Enterprise Resource Planning, які мають широкий функціонал та здебільшого відповідають потребам великих аграрних підприємств. Також, дослідження охоплює розгляд альтернативних інструментів для контролю та обліку, які можуть більше підходити для малих та середніх підприємств завдяки їхній простоті, цільовому спрямуванню та невисоким витратам на впровадження. Через оцінку агросфери України у роботі доведено важливість сільського господарства для держави, що пояснює необхідність пильної уваги до процесів цифровізації в галузі. В якості ефективної системи для реалізації контролю та обліку на національних агропідприємствах, розглянуто BAS АГРО. ERP. У підсумку дослідження відзначено можливості та загрози, слабкі та сильні сторони цифровізації контрольно-облікових процесів загалом. Також, визначено політичні, економічні, соціальні та технологічні фактори, що впливають на ці процеси в Україні

► **Ключові слова:** сільське господарство; програмні продукти; інновації; Enterprise Resource Planning; фінансовий менеджмент; аудит



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Development of the entrepreneurial ecosystem for the agricultural sector in Ukraine during wartime

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► **Abstract.** Enterprises that conduct and ensure the production of agricultural products, their processing and promotion to domestic and foreign markets objectively function in a close relationship, which provides certain savings it also makes the entire chain vulnerable to the negative impact of external factors. The purpose of the study was to conduct an economic assessment of trends in its development under the influence of wartime. Its economic essence, structure, and functional characteristics were theoretically justified, namely: the features of the development of the agricultural sector of Ukraine and the nature of its transformations under the influence of multidirectional changes in the conditions of wartime influence are determined. The interdependence of efficiency and economic efficiency of enterprises belonging to ecosystem sectors was established and methodically justified. Trends in the formation of economic results in a destructive institutional environment were systematised and updated. The problems of modern trends in the development of the ecosystem were methodically processed and the assessment of the following was conducted: structural changes in the composition of business formations, employment of the population in business formations; changes in the material base, the volume of products sold and the profitability of ecosystem enterprises. The assessment was conducted across distinct stages of armed aggression, analysing various sectors of the ecosystem: "agriculture"; "food production"; "manufacture and trade of agricultural resources"; "trade

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of agricultural products”; and “trade of food products”. The assessment also considered the primary size groups, namely large enterprises and small to medium-sized enterprises. The high tightness of the relationship between the parameters of activity of enterprises of the ecosystem of the agricultural sector was proved, which has a systemic character, and the factor of income from the sale of agricultural products was highlighted as the most substantial for its functioning. The results contributed to understanding the patterns of interdependence between the size and effectiveness of management in agricultural ecosystem enterprises operating as an integral entity under wartime conditions. This understanding is crucial for achieving sustainability, enhancing competitiveness, and, most importantly, ensuring the economic and physical preservation of each specific enterprise

► **Keywords:** entrepreneurship; business ecosystem; economic structures; economic activity; institutional structure; agriculture

► Introduction

The main factor in the development of the agricultural sector of the economy in Ukraine is the military: formally – martial law, and functionally – wartime. Business entities are forced to adapt to difficult situations in the organisation of production, staffing, and search for available sales channels. The military factor in general destructively affects the development of the entrepreneurial ecosystem of the agricultural sector of the Ukrainian economy. Accordingly, the meaning of research developments in the current state and performance of enterprises in various aspects of economic activity in agriculture is updated to determine strategic priorities for ensuring sustainability. According to this statement of the problem and to prove the projected hypothesis that agricultural business represents resistance to destructive influences, there are grounds for the examination of the problems of development of the community of agricultural business as an ecosystem, including such aspects as: structural changes in the composition of business formations; employment of the population; sales of manufactured products; trends in production costs; formation of revenue and profitability of economic activity.

Business entities, and therefore ecosystem participants, can have different plans and expectations while making joint efforts to achieve a common goal – value creation. They demonstrate a willingness to cooperate, considering all types of consumer behaviour, which depends not only on external factors but also on the characteristics and worldview of the buyer (Balaniuk *et al.*, 2023). The need to understand the management of entrepreneurial ecosystems in the context of complex relationships and conditions that define the work of modern business is an urgent problem for researchers (Shelenko *et al.*, 2024).

Businesses, for effective functioning in the entrepreneurial ecosystem, need reliable business models that should be aimed at their stable operation and development and that will allow them to differentiate and achieve sustainable competitive advantages. However, according to U. Pidun *et al.* (2022a) in entrepreneurial ecosystems, some characteristics distinguish them from other management models in such parameters as: modularity; customisation; multilateralism; coordination. Thus, an effective entrepreneurial ecosystem should demonstrate how businesses generate value for their customers and identify areas of collaboration with partners, customers, and suppliers, while considering the unique combination of resource availability. L. Paschuk & E. Tavoletti (2023) note that entrepreneurial ecosystems can be developed externally – through the creation of a favourable environment

for entrepreneurship, so they can be the subject of the influence of state policy for the development of the industry.

U. Pidun *et al.* (2022a) define the following types of entrepreneurial ecosystems that can be found in practice: decision ecosystems (create and/or provide a product or service by coordinating different participants); transaction ecosystems (select partners by determining the best match between the actual needs of the customer and the specific offer of the manufacturer). The success of the ecosystem model: at the launch stage (the model can quickly provide access to opportunities that can be too expensive or time-consuming to create in one firm); after the launch of the ecosystem (they can scale much faster than a separate business since their modular structure makes it easy to add partners); ecosystems are very flexible and sustainable (their modularity provides both great diversity and high development capacity) (Pidun *et al.*, 2022b). The perception of an entrepreneurial ecosystem as a permanent structure can also be fragile due to unrealistic or permanent changes and uncertainty during wartime and risks.

The analysis of literature sources and publications of researchers on the problems of entrepreneurship gives grounds, based on the practical and methodological nature of this socio-economic phenomenon, to reasonably note its multipolarity. In the organisational and functional plan of institutionalisation, this is extrapolated to the qualification of the entrepreneurial ecosystem as a component of the market mechanism that forms the economic capabilities of society, the state, society, and the individual to achieve certain goals in life.

A special context of theoretical, methodological, and empirical assessments of the development of the entrepreneurial ecosystem is expressed in the institutional identification of the category “enterprise”. The basis of the economic essence of entrepreneurial activity is not only the organisational structure but also the socio-cultural sphere, traditions, customs, and morals (Malik, 2023b), which characterise the entrepreneurial ecosystem as a socio-economic model of interaction that can manifest itself in cooperation (Malik, 2023a), depends on social capital. When examining entrepreneurial ecosystems or business ecosystems in Ukraine, the wartime factor is considered. The problem of the development of agricultural entrepreneurship in Ukraine as a nationally identical ecosystem of economic knowledge exchange has been implemented in practice under the latest conditions – wartime (Malik, 2023a; 2023b).

The actual aggressive impact of Russia's war against Ukraine entails devastating consequences, irretrievable

losses, and the destruction of property complexes of agricultural business ecosystems. O. Skydan *et al.* (2023) argue that the Russian invasion has led to the destruction of established processes and logistics chains in the agricultural sector. Such realities of the current state of Ukrainian agriculture have and will have a destructive impact on the development of business structures, villages, and territorial communities. The physical destruction of the economic structure exerts unprecedented pressure on society and the state in matters of food, economic, and energy security. The study aimed to provide a theoretical substantiation of the economic essence and functional characteristics of entrepreneurial ecosystems of the agricultural sector of Ukraine and economically assess trends in its development under the influence of wartime.

► Materials and methods

The study presents the results of the research obtained during the implementation of the project “Develop methodological approaches to determining losses, assessing the impact of military aggression and compensation policy on the development of agricultural entrepreneurship” No. 2022.01/0145 of the competition “Science for the restoration of Ukraine in the war and post-war periods” at the expense of grant support from the National Research Foundation of Ukraine (Project competition for..., 2022).

The ecosystem of entrepreneurship in the agricultural sector of Ukraine has long been in a state of transformation and adaptation to the conditions of various instabilities. The methodology of institutionalism was applied to the analysis of formation, development, and functioning of the entrepreneurship ecosystem in the agricultural sector. Its practicality consists in analysing the evolutionary changes in the composition and structure of entrepreneurial entities that guide business transactions in the agricultural market.

For the empirical analysis of changes in the parameters of the ecosystem of agricultural entrepreneurship, methods of dynamic series analysis were applied using indicators of growth rates and average growth rates

calculated for periods that characterise the main stages of Russian aggression identified based on abstract-logical analysis: pre-war period (2010-2013); the beginning of the first phase of armed aggression (2014); latent period with the localisation of the conflict in the South-Eastern regions (2015-2021); the period of acute phase of Russian armed aggression (2022 and 2023). The official website of the State Statistics Service of Ukraine (n.d.), in particular: “The number of enterprises by types of economic activity divided into large, medium, small, and microenterprises”; “the number of employees engaged at enterprises by types of economic activity divided into large, medium, small, and microenterprises”; “the volume of products sold (goods, services) of enterprises by types of economic activity divided into large, medium, small, and microenterprises”; “financial results before taxation of enterprises by types of economic activity divided into large, medium, small, and microenterprises”; “non-current and current assets, equity, and liabilities of large and medium-sized enterprises by type of economic activity”. Updating information as of 2023 on the latest data set was postponed by the state statistics service of Ukraine due to martial law for an indefinite period, so the corresponding analysis table and correlation analysis used data for 2010-2022 inclusive. However, given a sufficient number of dynamic series and a wide range of institutional changes covering the selected period, this allows considering the main trends in changes in business conditions and does not reduce the validity of conclusions. A special feature of the study was the use to determine the composition of the ecosystem of groups of enterprises aggregated by the same types of economic activity, directly related to the production, processing, and further promotion of agricultural products.

Correlation analysis was used to determine the interdependence of enterprise activity parameters in the ecosystem. The analysis was conducted based on deviations of the actual values of indicators from the calculated ones obtained from the trend equations (Table 1) to offset the trend of increasing the values of indicators over time, including due to inflationary factors.

Table 1. Trend equations for enterprise activity parameters within the agricultural entrepreneurship ecosystem (based on data from 2010-2022)*, **

Materials and methods	Number of employees	Operating Profit (OP)	Financial outcome	Value of fixed and intangible assets
<i>Agricultural production</i>				
$\hat{y} = -0.1865x^3 + 2.7071x^2 - 10.741x + 56.375$ $R^2 = 0.9138$	$\hat{y} = -0.8513x^3 + 13.697x^2 - 78.062x + 674.59$ $R^2 = 0.9623$	$\hat{y} = 145.24x^{0.7042}$ $R^2 = 0.8693$	$\hat{y} = 17.72x^{0.8944}$ $R^2 = 0.392$	$\hat{y} = -0.9909x^3 + 16.347x^2 - 41.949x + 109.78$ $R^2 = 0.998$
<i>Food production:</i>				
$\hat{y} = -0.0202x^3 + 0.3327x^2 - 1.5529x + 6.6108$ $R^2 = 0.8023$	$\hat{y} = -0.8746x^3 + 15.167x^2 - 81.67x + 410.41$ $R^2 = 0.9813$	$\hat{y} = 0.0641x^4 - 1.557x^3 + 12.642x^2 - 37.396x + 27.009$ $R^2 = 0.874$	$\hat{y} = -0.0202x^3 + 0.3327x^2 - 1.5529x + 6.6108$ $R^2 = 0.8023$	$\hat{y} = -0.3504x^3 + 6.0156x^2 - 16.746x + 69.812$ $R^2 = 0.9946$
<i>Production and trade of agricultural resources:</i>				
$\hat{y} = -0.0065x^3 + 0.1018x^2 - 0.3934x + 1.51$ $R^2 = 0.9413$	$\hat{y} = -0.0484x^3 + 0.5919x^2 - 1.4923x + 27.824$ $R^2 = 0.7361$	$\hat{y} = 17.364x^{0.6892}$ $R^2 = 0.8445$	$\hat{y} = 0.0089x^4 - 0.194x^3 + 1.3567x^2 - 2.8706x + 1.2761$ $R^2 = 0.6179$	$\hat{y} = -0.0061x^3 + 0.0733x^2 + 0.4527x + 2.0081$ $R^2 = 0.9583$

Table 1, Continued

Materials and methods	Number of employees	Operating Profit (OP)	Financial outcome	Value of fixed and intangible assets
<i>Trade of agricultural products</i>				
$\hat{y} = -0.0255x^3 + 0.3863x^2 - 1.5407x + 5.0698$ $R^2 = 0.8538$	$\hat{y} = -0.0169x^3 - 0.0853x^2 + 2.8928x + 20.74$ $R^2 = 0.6811$	$\hat{y} = 74.26x^{0.5956}$ $R^2 = 0.8365$	$\hat{y} = -0.2493x^3 + 3.7712x^2 - 14.622x + 8.3158$ $R^2 = 0.6935$	$\hat{y} = -0.0967x^3 + 1.2364x^2 - 0.4229x + 8.2396$ $R^2 = 0.9693$
<i>Trade of food products:</i>				
$\hat{y} = -0.0233x^3 + 0.3738x^2 - 1.6648x + 5.2571$ $R^2 = 0.8111$	$\hat{y} = -0.2382x^3 + 4.0733x^2 - 18.948x + 55.444$ $R^2 = 0.9791$	$\hat{y} = -0.4705x^3 + 8.0337x^2 - 21.975x + 84.639$ $R^2 = 0.9755$	$\hat{y} = 0.0641x^4 - 1.557x^3 + 12.642x^2 - 37.396x + 27.009$ $R^2 = 0.874$	$\hat{y} = 0.0661x^4 - 1.3357x^3 + 8.4406x^2 - 16.556x + 19.092$ $R^2 = 0.6742$

Note: * $\hat{y}$ – calculated value of the parameter obtained from the trend equation; ** R^2 (coefficient of determination) – characterises the level of reliability of approximation (approximation) of the values of the obtained model to the actual values of parameters

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

The dynamics of changes in most indicators are described by the polynomial approximation method, which allows considering their changing fluctuations under the influence of natural and socio-economic factors. However, changes in the volume of products sold by sectors of agriculture, production and trade of material resources for agriculture, and trade in agricultural products are described using a power function that reflects a high dependence on the growth of the exchange rate due to the directing these industries to foreign markets. High values of the coefficients of determination indicate the reliability of the approximation of trend equations.

► Results and Discussion

The activity of agricultural entrepreneurship entities-participants in the development of the entrepreneurial ecosystem of economic activity in the agricultural sector of the Ukrainian economy, in the last two years was somehow institutionally blocked by the destructive influence of wartime conditions. Among the blocking factors: limited access to the channels of sales of products, in particular, export; a cardinal increase in the cost of forming factors of production and the volume of transaction costs of exchange; deterioration of the quantitative and qualitative characteristics of the personnel potential of enterprises and labour – rural areas (Shyian *et al.*, 2023).

In the conditions of wartime, the institutional conditions for the development of agricultural entrepreneurship radically changed, which determined the levels of acquired economic effects and social results of management. Thereby, in the development of entrepreneurship in general and agricultural enterprises in particular, the tasks have not changed – the conditions for achieving the goals have changed. Institutional changes affect the organisational and economic functionality of economic entities.

From empirical assessments of the processes taking place in the agricultural sector of the economy, it is known about multidirectional changes in the structure and composition of enterprises. The sector is formed institutionally as part of subjects formalised by status: type (agricultural enterprises, farms); organisational and legal form (economic companies, private, state, municipal enterprises, cooperatives, farms, etc.); size of the enterprise (micro-, small-, medium-, large-sized); type of economic activity. Such characteristics of entrepreneurship are due

to a long evolution to market conditions. Therewith, none of the subjects, including the relevant state authorities, has superior power and control, which makes traditional approaches to ensuring the development of agricultural production ineffective in the face of military threats.

Among the economic concepts that explain the mechanisms of development of economic communities, an ecosystem approach was chosen for this study, focusing on the subjects of the business system and ways of interaction between them. R. Röntynen (2024) notes the lack of hierarchy as a characteristic feature of ecosystems that “arise spontaneously – from the totality of relationships between individual agents and external influences”. This statement is fully suitable for explaining the practice of functioning of the agricultural sector of the Ukrainian economy in the context of critical phenomena accompanying martial law.

J.F. Moore (1996) defined the entrepreneurial ecosystem, or, we consider it appropriate to use the definition of the entrepreneurship ecosystem (auth.), as “a growth-oriented synergistic economic community of mutually supporting customers, suppliers, treating producers and other stakeholders, trade associations, standardisation bodies, trade unions, state, and quasi-state institutions”. The study agrees with this definition in general and proposes to methodically qualify it from an institutional standpoint as a set of market stakeholders involved in transactions in the area of “production-distribution-exchange-consumption” for profit. More broadly – the economic, productive, social, and economic aspects of the effect of increasing benefits to meet market demand (Moore, 1996).

It is reasonable to fully agree with B. Spigel & R. Harrison (2018), who concluded that the functioning of ecosystems stems from the socially embedded nature of the entrepreneurship process, which includes a wide range of actors, resources, and opportunities. Notably, the ecosystem performs the functions of institutionalising social capital, using the rules, norms, and traditions of organising social interaction to form a supportive business environment (Yatsiv *et al.*, 2024). The definition of characteristics and development of the entrepreneurial ecosystem in the agricultural sector are related to industry specifics. First, with the influence of natural factor, seasonality of production, properties of agricultural products and food, etc. This study agrees with B. Pohrishchuk *et al.* (2023) that

a separate destabilising factor is the low level of entrepreneurial activity of the rural population. This factor affects the method of production and storage of products, the organisation of labour and management, and, in particular, the organisation and implementation of business transactions in general. Thus, the development of the entrepreneurial ecosystem in Ukraine takes place in the context of the institutional uncertainties of wartime. It is worth agreeing with I. Kalenyuk & I. Uninets (2021) on the expediency of using the economic status to interpret the essence and functionality of an ecosystem “when economic phenomena and processes are part of the interaction of biological, physical, environmental, and other processes”.

Traditional definitions of entrepreneurship we consider to be the qualification of its essence as an ecosystem. In this sense, the imperative of evolutionism is methodologically implemented, because: economic structures of entrepreneurial activity are formed in an evolutionary way, and their typology and structuring depend on the trajectory of society's Development (Malik, 2023b). Entrepreneurship is defined as an institutional system of economic interactions (Malik, 2023b), which functions, among other things, in conditions of wartime uncertainty (Zhuk et al., 2023). Other researchers assume that if the economic system assumes the presence of entrepreneurial structures, then its integral component is entrepreneurial ecosystems as an environment for the growth of firms (Porev, 2018). Thus, the importance of the entrepreneurial ecosystem as a mechanism for accumulating and spreading innovations through the corresponding model of their diffusion – academic and university structure is noted.

There is also an opinion, which can be considered appropriate, that entrepreneurial ecosystems are not only innovation parks but also other partner associations (Paschuk, 2021). Positioning of entrepreneurial ecosystems takes place at various institutional levels – micro-, meso-, and macro-level interactions in a competitive market environment. As quite rightly stated L. Paschuk (2021), an entrepreneurial ecosystem is a collection of legal entities and individuals of different sectors, different in nature of activities, which functions for the development of innovation and entrepreneurship by

combining the efforts of different groups of stakeholders. Based on the above and the provided methodological generalisations – entrepreneurial ecosystems are classified according to institutional, organisational, and economic characteristics – at the following levels: *integrated structures* – coalition (cooperatives, clusters, holdings); *the institute of regulation* – the infrastructure of self-regulatory organisations (professional, interprofessional, industry associations); *business entities* – enterprises of various organisational and legal forms (business companies, private, state-owned enterprises); *scientific and educational infrastructure* – academic and university entrepreneurship (scientific and industrial parks, start-up systems); *industries* – agricultural (agricultural enterprises, farms); *organisational and economic socialisation of economic management* – economic (classical enterprises) and social entrepreneurship (social enterprises). These methodological provisions for determining the essence of entrepreneurial ecosystems denote the institutional structure of the economic system of the national economy, the agricultural complex in particular.

In the agricultural sector of the Ukrainian economy, a nationally identical entrepreneurial ecosystem has been formed based on the institutional approach (auth.), projected onto the community of “organisms of the business world” (Moore, 1996). The entrepreneurial structure of the ecosystem is formed by business entities, i.e., enterprises of various types in the form of ownership (state, collective, individual, municipal), sizes (micro-, small-, medium-, and large-sized enterprises), organisational and legal forms (economic societies of various types, cooperatives, public, private, municipal enterprises, etc.), and institutional statuses (individuals-entrepreneurs, legal entities) (Fig. 1). The study also believes that in the analysis of the development of the entrepreneurial ecosystem in the agricultural sector of the Ukrainian economy, it is methodologically motivated to characterise it according to the definitions of institutional subsystems such as: integrated formations – respectively agricultural holdings and cooperatives, clusters, organisations of producers; ecosystems for the creation and diffusion of innovations – structures of academic and university entrepreneurship, etc.

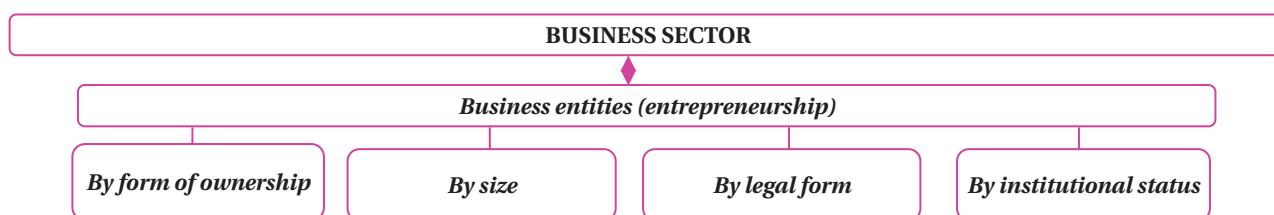


Figure 1. Entrepreneurial ecosystem of the agricultural sector of Ukraine*

Source: compiled by the authors

In the market-oriented evolution of the economic mechanism, a relatively well-established entrepreneurial ecosystem has been formed in Ukraine (Fig. 2), which has acquired structural adaptation to national and global institutions, and conditions of functioning based on sustainability. Due to this, Ukraine has become a global player in the global agricultural markets, and enterprises have gained a substantial level of competitiveness.

The analytical attention is focused on conducting empirical assessments of the evolution of development and determining the effectiveness of the entrepreneurial ecosystem of the agricultural sector, in particular, considering the conditions of wartime. *The object of the study is the institutional set of enterprises by size – micro-, small-, medium-, large-.* The dimension criterion comprehensively considers all possible business statuses. That is why

this criterion was chosen to conduct research to identify the features, specifics, and institutional foundations of the

development of this ecosystem in Ukraine in the current difficult period.

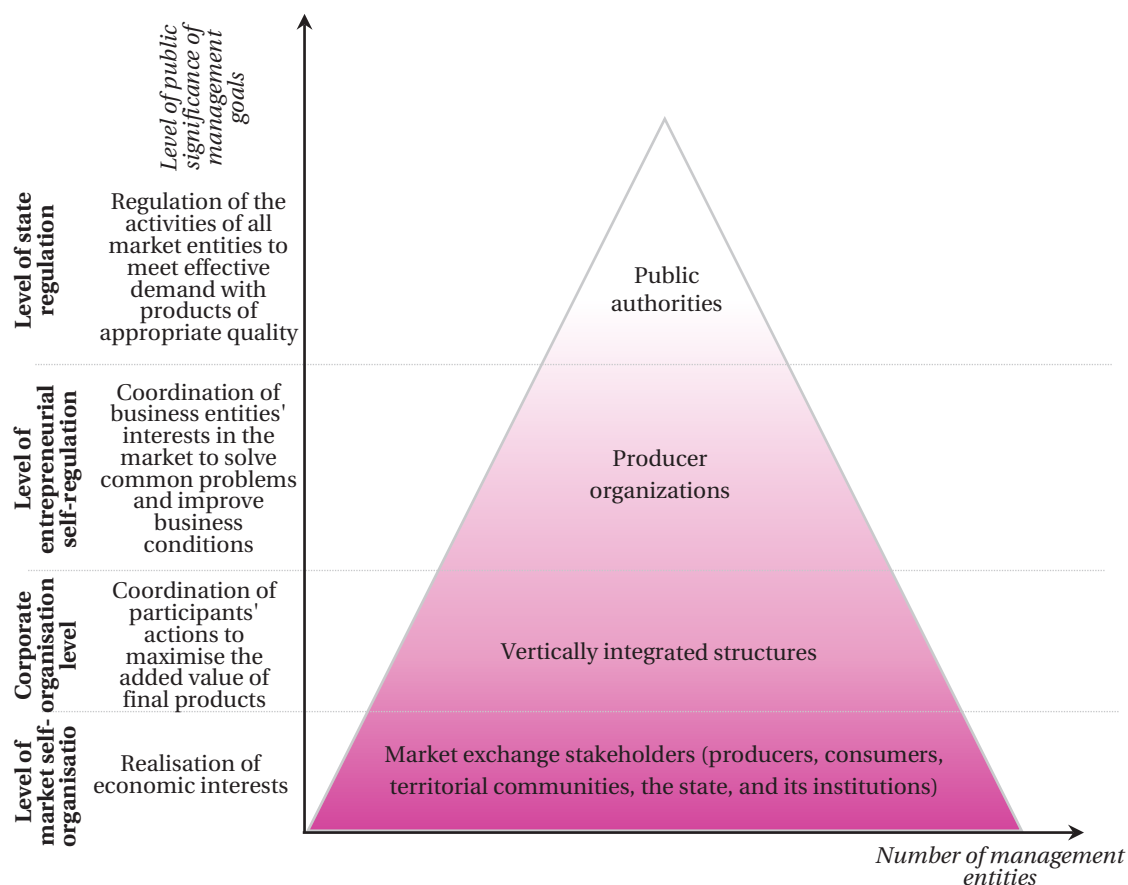


Figure 2. Institutional structure of the agricultural entrepreneurship ecosystem

Source: compiled by the authors

Agriculture with a plume of related industries occupies an important place in the national economy. The ecosystem of agriculture includes enterprises that conduct economic activities in the following aggregated groups of economic activities: directly agriculture; food production,

production and trade in material resources for agriculture; trade in agricultural products; trade in food industry products. Including the period of recent wartime history, structural changes in the composition of entrepreneurial formations occur (Table 2).

Table 2. Structural changes in the composition of entrepreneurial formations in Ukraine (agricultural activities), un.

Types of economic activity (NACE)	Periodisation of structural changes									
	2010	2013	Pace of change, 2010 – 2013%	2014	2014 to 2013, %	2015	2021	Pace of change, 2015 – 2021%	2022/2023	2022 to 2021, %/ 2023 to 2021, %
Business sizes										
All businesses										
Agriculture	49,060	47,826	99.2	44,180	92.4	44,897	46,070	100.6	31,740/ 39,638	68.9/ 86.0
Food production:	5,444	5,321	99.2	4,637	87.1	4,657	5,293	101.9	3,985/ 4,609	75.3/ 87.1
Production and trade of material resources for agricultural enterprises	1,019	1,180	105.0	1,107	93.8	1,127	1,572	105.1	1,216/ 1,375	77.4/ 87.5
Trade in agricultural products	3,311	3,749	340.5	3,454	92.1	3,499	4,313	103.2	2,616/ 3,776	60.7/ 87.5

Table 2, Continued

Types of economic activity (NACE)	Periodisation of structural changes									
	2010	2013	Pace of change, 2010 – 2013%	2014	2014 to 2013, %	2015	2021	Pace of change, 2015 – 2021%	2022/2023	2022 to 2021, %/ 2023 to 2021, %
Business sizes										
Trade of food products:	3,563	3,811	102.3	3,308	86.8	3,328	3,977	102.7	2,500/ 3,189	62.9/ 80.2
Small businesses										
Agriculture	45,972	45,246	99.5	41,885	92.6	42,668	44,231	100.8	30,221/ 38,202	68.3 86.4
Food production:	4,276	4,296	100.2	3,742	87.1	3,785	4,414	102.4	3,211/ 3,868	72.7/ 87.6
Production and trade of material resources for agricultural enterprises	929	1,082	105.2	1,015	93.8	1,033	1,460	105.3	1,114/ 1,283	76.3/ 87.9
Trade in agricultural products	3,138	3,534	104.0	3,281	92.8	3,360	4,140	103.4	2,501/ 3,648	60.4/ 88.1
Trade in food industry products	3,336	3,597	102.5	3,139	87.3	3,180	3,801	102.8	2,354/ 3,037	61.9/ 79.9
Large and medium-sized enterprises										
Agriculture	3,088	2,580	94.2	2295	89.0	2,229	1839	96.9	1,519/ 1,436	82.6/ 78.1
Food production:	1,168	1,025	95.7	895	87.3	872	879	99.7	774/ 741	88.1/ 84.3
Production and trade of material resources for agricultural enterprises	90	98	102.9	92	93.9	94	112	102.9	102/ 92	91.1/ 82.1
Trade in agricultural products	173	215	107.5	173	80.5	139	173	100.0	115/ 128	66.5/ 74.0
Trade in food industry products	227	214	98.1	169	79.0	148	176	100.6	146/ 152	83.0/ 86.4

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

The dimension of enterprises in conditions of war-time uncertainty and market turbulence objectively affects their competitiveness and institutional stability. The latter means the actual ability of the enterprise to remain in the market, that is, to function with an excess of economic benefits over costs. In the opposite case, that is, with negative performance, farms go bankrupt, and entrepreneurs wind down their businesses. Under the conditions of the military factor, there is simultaneous physical destruction of the business. As can be seen from the table, this trend took place already at the first stage of the beginning of the Russian armed aggression against our state in 2014. Since at that time the occupation and fighting were geographically localised in the Luhansk, Donetsk regions and Crimea – regions specialised in non-agricultural economic activities, the decrease in the number of enterprises occurred to a greater extent in the food industry (by 12.9%) and food trade (by 13.2%). Since the beginning of large-scale armed aggression in 2022 and until now, the risks of losing an enterprise due to destruction as a result of military operations have been extremely high throughout the entire territory of the state. According to the analysis of structural changes in the composition of entrepreneurial formations that make up the national agroecosystem (Table 2) a substantial

decrease in them occurred in all its segments. Substantial changes occurred in the group of small enterprises, where the reduction in the number compared to 2021 amounted to 31.7% for agriculture, 38.6% for enterprises that traded in agricultural products, and 38.1% – for food trade. The latter segments have suffered substantially for all groups of enterprises due to the physical damage to the domestic logistics infrastructure and the blocking of traditional ways to supply Ukrainian agri-food products to world markets. In 2023, the number of enterprises increased to about 87% of the level of 2021 in all parts of the business ecosystem of the industry, except for the food trade, where growth occurred at a slower pace. This is due to the fact that large and medium-sized enterprises have acquired a relatively stable competitive position in this group, the number of which in 2023 increased to 86.4% in 2021. However, in other industries, the recovery was mainly at the expense of small businesses that demonstrate sustainability while operating within the current market niche, inheriting the flexibility and adaptability of this form of business. Large and medium-sized business entities are less resistant to conditions of uncertainty and high risk of business.

A separate factor that has a substantial impact on the possibility of doing business in segments of the agricultural

entrepreneurship ecosystem is changes in the size and employment structure of the economically active population. Active military operations have led to the

intensification of migration processes, which leads to a decrease in the number of people employed in ensuring the functioning of these sectors of the economy (Table 3).

Table 3. Employment trends in the development of entrepreneurial formations in Ukraine (agricultural activities), thousand people

Types of economic activity (NACE)	Periodisation of structural changes									
	2010	2013	Pace of change, 2010 – 2013%	2014	2014 to 2013, %	2015	2021	Pace of change, 2015 – 2021%	2022/2023	2022 to 2021, %/ 2023 to 2021, %
	Business sizes									
All businesses										
Agriculture	688.4	613.8	96.3	561.1	91.4	528.5	478.9	97.8	406.8/ 379.4	84.9/ 78.9
Food production:	352.8	344.5	99.2	298.0	86.5	278.9	272.0	98.7	233.9/ 226.7	3.4/ 83.3
Production and trade of material resources for agricultural enterprises	31.2	27.2	95.5	26.3	96.5	27.6	28.4	101.1	23.4/ 21.0	82.2/ 73.8
Trade in agricultural products	27.1	24.2	72.3	24.3	100.6	29.1	28.8	102.5	23.8/ 24.3	82.6/ 84.4
Trade in food industry products	51.4	40.0	92.0	32.3	80.9	29.1	42.2	103.9	34.5/ 36.2	81.7/ 85.8
Small businesses										
Agriculture	209.6	227.2	102.7	208.1	91.6	193.9	220.3	100.8	181.5/ 168.4	82.4/ 76.5
Food production:	41.2	37.8	97.2	31.5	83.4	30.9	34.0	101.1	29.2/ 29.5	85.9/ 86.7
Production and trade of material resources for agricultural enterprises	6.9	7.3	102.2	7.0	95.6	6.6	9.5	104.4	8.0/ 7.5	85.0/ 79.8
Trade in agricultural products	12.4	11.6	97.8	10.9	94.4	10.5	13.1	102.6	10.7/ 11.4	81.3/ 86.9
Trade in food industry products	18.0	15.3	94.8	13.4	87.8	12.9	15.6	102.2	11.8/ 11.5	75.5/ 74.0
Large and medium-sized enterprises										
Agriculture	478.8	386.6	93.1	352.9	91.3	334.6	258.7	95.7	225.3/ 211.0	87.1/ 81.0
Food production:	311.6	306.7	99.5	266.5	86.9	248.0	238, tsh1	98.4	204.7/ 197.3	86.0/ 82.9
Production and trade of material resources for agricultural enterprises	24.3	19.9	93.5	19.2	96.8	21.1	19.0	99.8	15.4/ 13.4	80.9/ 70.8
Trade in agricultural products	14.6	12.6	95.0	13.4	106.3	18.6	15.7	102.3	13.1/ 12.9	83.7/ 82.3
Trade in food industry products	33.4	24.7	90.4	18.9	76.6	16.2	26.6	105.0	22.7/ 24.6	85.4/ 92.7

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

Notably, employment in conventional agriculture and related sectors has been influenced by changes in the institutional model of management, wherein the development of large-scale integrated structures has led to a decrease in the number of employed individuals,

particularly in medium-sized enterprises affiliated with such formations. This situation has increased the role of small enterprises, which serve not only as places of employment but also as the primary arena for the entrepreneurial initiatives of the economically active population

in rural areas. Consequently, the decline in employment within this group of enterprises significantly contributes to the reduction in their number. In terms of industry, the agricultural product trade has experienced the greatest loss in terms of employed workers, corresponding with the trend of decreasing numbers of enterprises in this sector. Despite an increase in the number of enterprises in 2023, employment levels across production sectors continue to decline. Small enterprises, particularly those where the majority of the workforce comprises the owners and their family members, have proven to be particularly vulnerable. Consequently, the trend in the number of businesses is closely aligned with the variation in employment levels. The impact of the war has exerted a fundamentally destructive influence on the operation of small enterprises, effectively selecting them based on the availability of labour – an important characteristic of the current situation. A significant number of workers have been mobilised, some members of the population remain

in temporarily occupied territories, and a substantial portion has become refugees, relocating to other countries. As a result, the sector is suffering from a shortage of labour resources, which is adversely affecting productivity. Notably, at present, the impact of this factor is not readily perceived. However, from a strategic perspective, it poses a threat of exerting a fundamentally destructive influence on the operation of small enterprises by selecting them based on the availability of labour – a salient characteristic of the current context.

Another critical factor directly influencing the feasibility of entrepreneurship within the agricultural sector and its related industries is the preservation of the material base for production activities. The competitiveness of modern agriculture and the sectors that support it is ensured through the use of productive agricultural machinery, livestock complexes, and logistical equipment. The condition of the material base is evaluated based on the residual value of fixed assets and intangible assets (Table 4).

Table 4. Trends in the preservation of the material base of entrepreneurial formations in Ukraine (agricultural activities), billion UAH

Types of economic activity (NACE)	Periodisation of structural changes							
	2013	2014	2014 to 2013, %	2015	2021	Pace of change, 2015 – 2021 %	2022	2022 to 2021, %
Business sizes								
All businesses								
Agriculture	81.8	85.5	104.6	103.7	338.7	121.7	332.3	98.1
Food production:	56.2	60.4	107.5	68.0	154.3	114.3	151.2	98.0
Production and trade of material resources for agricultural enterprises	2.4	3.2	132.6	4.4	8.4	115.0	7.3	86.8
Trade in agricultural products	8.8	12.6	143.8	13.4	34.6	115.5	30.9	89.4
Trade in food industry products	10.5	9.7	92.6	10.4	16.6	107.9	21.0	126.9
Small businesses								
Agriculture	30.0	31.8	106.1	39.1	136.5	123.1	139.7	102.3
Food production:	4.1	4.7	115.3	5.1	13.3	116.0	13.1	98.3
Production and trade of material resources for agricultural enterprises	0.5	0.6	106.0	0.6	2.2	121.6	1.9	88.6
Trade in agricultural products	1.4	1.9	140.4	1.4	2.9	106.2	3.5	121.4
Trade in food industry products	1.1	1.4	133.9	1.2	1.7	103.0	2.0	112.3
Large and medium-sized enterprises								
Agriculture	51.8	53.7	103.7	64.6	202.2	120.9	192.7	95.3
Food production:	52.1	55.7	106.8	63.0	141.1	114.2	138.2	97.9
Production and trade of material resources for agricultural enterprises	1.9	2.6	140.1	3.8	6.3	113.3	5.4	86.2
Trade in agricultural products	7.4	10.7	144.4	12.0	31.7	116.8	27.4	86.5
Trade in food industry products	9.4	8.3	88.0	9.2	14.8	108.6	19.1	128.6

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

The favourable conditions of the world markets of agricultural products ensured the rapid development of the material base of agricultural activities: the average annual increases in the residual value of fixed assets and intangible assets reached 15-20% in all sectors of the agri-food ecosystem and in enterprises of all sizes. The armed aggression against Ukraine caused direct losses related to the direct destruction of the production base, logistics equipment, and loss of property in the occupied territories. Notably, for the group of small enterprises in agriculture and trade in agricultural products in 2022, it

was possible to maintain an increase in fixed assets, which is due to the peculiarities of the territorial location and specialisation of such enterprises, as well as the unique capabilities of such enterprises to relocate production to safer territories of the country. The main source of funds received to finance current activities and investments in the further development of enterprises is income from the sale of manufactured products. Therefore, this factor is determined as specific and determinative in its effectiveness in influencing the development of business sectors for the production of agri-food products (Table 5).

Table 5. Trends in sales of products of entrepreneurial formations in Ukraine (agricultural activities), billion UAH

Types of economic activity (NACE)	Periodisation of structural changes									
	2010	2013	Pace of change, 2010 – 2013%	2014	2014 to 2013, %	2015	2021	Pace of change, 2015 – 2021%	2022/2023	2022 to 2021, %/ 2023 to 2021, %
Business sizes										
<i>All businesses</i>										
Agriculture	94.8	153.9	117.5	205.2	133.3	349.7	891.0	123.3	651.9/ 752.6	73.2/ 84.5
Food production:	158.4	227.2	112.8	265.7	117.0	339.6	742.7	115.8	672.6/ 778.5	90.6/ 104.8
Production and trade of material resources for agricultural enterprises	13.5	18.1	110.3	21.7	119.8	34.6	91.3	122.8	74.0/ 84.9	81.0/ 93.0
Trade in agricultural products	63.2	74.2	89.7	100.9	136.0	156.9	334.4	118.7	232.4/ 270.2	69.5/ 80.8
Trade in food industry products	66.7	67.0	100.1	74.5	111.2	80.1	211.3	116.1	190.7/ 248.5	90.3/ 117.6
<i>Small businesses</i>										
Agriculture	21.9	48.1	130.0	64.4	133.9	116.4	325.7	126.1	254.3/ 288.1	78.1/ 88.4
Food production:	8.4	12.0	112.7	13.9	116.3	21.2	43.0	117.5	43.8/ 55.3	101.8/ 104.8
Production and trade of material resources for agricultural enterprises	3.3	4.1	107.9	5.3	127.8	7.3	22.2	122.7	18.4/ 23.4	83.0/ 105.5
Trade in agricultural products	19.1	19.7	101.1	24.5	124.1	36.1	67.0	115.5	54.3/ 61.6	81.1/ 92.0
Trade in food industry products	15.6	16.8	102.5	18.8	112.4	23.5	60.4	118.1	51.9/ 61.3	3.4/ 94.6
<i>Large and medium-sized enterprises</i>										
Agriculture	73.0	105.9	113.2	140.9	133.0	233.2	565.3	122.0	397.7/ 464.5	70.4/ 82.2
Food production:	150.1	215.2	112.8	251.8	117.0	318.4	699.7	115.7	628.8/ 723.2	89.9/ 103.4
Production and trade of material resources for agricultural enterprises	10.3	14.3	111.4	16.9	118.0	28.4	70.0	122.6	61.1/ 61.5	88.9/ 89.0
Trade in agricultural products	44.1	54.5	107.3	76.4	140.4	120.9	267.4	119.6	178.0/ 208.6	66.6/ 78.0
Trade in food industry products	51.1	50.2	99.4	55.6	110.8	56.6	150.9	115.3	138.8/ 187.2	92.0/ 124.1

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

As noted above, the situation of global agri-food markets for the period covered by the study was extremely favourable, which allowed increasing the volume of products sold in value terms for all industries and size groups of enterprises of agri-food activities with an average annual rate of more than 20% in agriculture and more than 15% in other industries. This increased the attractiveness of the agricultural sector for doing business and stimulated the creation of new enterprises here, but formed a specific export-oriented production structure. The beginning of large-scale military operations was accompanied by the blocking of the seaports of the Black and Azov seas and the physical destruction of logistics infrastructure, which disrupted the traditional ways of promoting products to external markets and caused substantial losses in sales volumes in terms of value, even under the inflationary factor. The greatest stability was demonstrated by enterprises engaged in the production and trade of food products, which, except for representatives of the fat and oil industry, met the needs of the internal market. In the field of agriculture, large enterprises with public status, qualified management, and a positive reputation have sufficient potential to restore the pace of development. Secure

product delivery routes have been developed and value-added chains have been revised. As part of European integration, businesses establish partnerships with European counterparties. Thus, KSG Agro has signed a memorandum of cooperation with the Polish company Makarony Polskie for joint processing and trade of finished products (KSG Agro has partnered..., 2022). However, a substantial drop in the cost of products sold among medium-sized enterprises offset the result for the group. This can be explained by the narrow specialisation of medium-sized enterprises in the production of purely export-oriented products, in particular, grain, the prices of which have fallen substantially on the Ukrainian market. In addition to the price factor, the physical volume of sales of these crops has also decreased due to the desire of producers to optimise harvesting costs. In 2023, the adaptation of enterprises to the crisis phenomena allowed the decline in sales volumes to stop all parts of the ecosystem.

In the conditions of unfavourable external factors, business entities realise their internal potential in accordance with the established development strategies. The success of this is realised in the possibility of maintaining profitability as a motivational basis for doing business (Table 6).

Table 6. Profitability trends in entrepreneurial formations in Ukraine (agricultural activities), billion UAH

Periodisation of structural changes								
Types of economic activity (NACE)	2013	2014	2014 to 2013, %	2015	2021	2021 to 2015, %	2022/2023	2022 to 2021, %/ 2023 to 2021, %
Business sizes								
All businesses								
Agriculture	15.0	21.5	143.2	102.0	238.5	233.8	85.7/ 60.1	35.9/ 25.2
Food production:	3.8	-14.9	-492.1	-15.7	12.7	181.0	3.9/ 33.7	30.6/ 265.1
Production and trade of material resources for agricultural enterprises	-0.006	-1.3	N/S	0.3	4.4	1,338.1	2.4/ 5.5	54.8/ 125.5
Trade in agricultural products	-0.8	-10.5	-1,244.2	-12.0	6.6	155.3	-11.7/ 2.6	-276.5/ 39.4
Trade in food industry products	1.1	-9.8	-1,020.3	-7.0	1.9	127.0	1.4/ 4.9	74.5/ 259.9
Small businesses								
Agriculture	4.3	7.1	165.5	34.1	88.3	259.4	28.3/ 24.6	32.1/ 27.8
Food production:	-0.9	-1.3	136.4	-0.8	-0.009	1.1	-2.6/ -0.9	N/S/ N/S
Production and trade of material resources for agricultural enterprises	-0.1	-0.7	458.5	0.0	1.2	4,610.0	0.4/ 1.4	36.3/ 118.8
Trade in agricultural products	-0.8	-4.2	-498.1	-3.9	0.3	107.2	-0.7/ 0.8	-335.3/ 168.8
Trade in food industry products	-0.2	-1.5	658.9	-1.0	0.6	165.6	-0.032/ -1.2	-105.2/ -298.2
Large and medium-sized enterprises								
Agriculture	10.7	14.4	134.3	67.9	150.1	221.0	57.4/ 35.5	38.2/ 23.6
Food production:	4.7	-13.7	-387.6	-14.9	12.7	185.3	6.5/ 34.6	51.1/ 272.1

Table 6, Continued

Types of economic activity (NACE)	Periodisation of structural changes							
	2013	2014	2014 to 2013, %	2015	2021	2021 to 2015, %	2022/2023	2022 to 2021, %/ 2023 to 2021, %
Business sizes								
Production and trade of material resources for agricultural enterprises	0.1	-0.7	-457.4	0.3	3.2	1,067.2	2.0/ 4.1	61.5/ 1427.9
Trade in agricultural products	0.0004	-6.3	N/S	-8.1	6.3	178.8	-11.0/ 1.9	-273.9/ 30.2
Trade in food industry products	1.3	-8.3	-738.2	-6.0	1.3	120.8	1.4/ 6.1	114.3/ 469.2

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

The production potential accumulated during favourable periods and the stable market position of agricultural producers allowed ensuring positive financial results (balances) of small, medium, and large enterprises of the sector, although with a substantial decrease in the volume of profits received. Against the background of the need to restore damaged machinery and equipment, profitability was provided by enterprises of all size groups for the production and trade of material resources for agriculture, which in the conditions of the first phase of military aggression turned out to be unprofitable. Small enterprises for the production and trade of food products became unprofitable in 2022, while large enterprises in these sectors provided minimal profit losses. The highest level of unprofitability is demonstrated by trade in agricultural products from blocking ports and the physical destruction of logistics infrastructure. In 2023, commercial enterprises of all sizes managed to adapt to unfavourable conditions and increase profits, but not in favour of agriculture, where profitability decreased.

The effectiveness of the functioning of the entrepreneurial system is associated with the achievement of high financial results by agricultural enterprises (Lupenko &

Lupenko, 2024) which should be agreed with, but the qualitative component is also important – financial results should not just be high, they should ensure a balance of benefits and costs at a level sufficient for extended reproduction.

In the entrepreneurial ecosystem of the agricultural sector, especially under the influence of wartime, such a result is difficult to ensure objectively – due to the existing institutional conditions. In addition, due to the dependence on the natural factor; diversity of forms of management; special, dependent on the social capital of territorial communities nature of the diffusion of innovations, etc. (Christensen *et al.*, 2019; Nair, 2020).

Enterprises of various sectors of the ecosystem of agricultural entrepreneurship show a specific reaction to the shock of Russian armed aggression, but it is necessary to be aware of the high level of interdependence between its various sectors, which has a well-established systemic nature. The calculated values of paired coefficients of the correlation matrix of the relationship between the number of enterprises in different sectors (based on deviations of the actual values of the indicator from the calculated ones – built based on trends in their development) indicate a close direct relationship between them (Table 7).

Table 7. Correlation matrix of interdependence of the number of enterprises between ecosystem sectors

	Number of agricultural enterprises	Number of food production enterprises	Number of enterprises for the production and trade of material resources for agricultural enterprises	Number of enterprises selling agricultural products	Number of food industry trade enterprises
Number of agricultural enterprises	1				
Number of food production enterprises	0.904	1			
Number of enterprises for the production and trade of material resources for agricultural enterprises	0.852	0.891	1		
Number of enterprises selling agricultural products	0.662	0.823	0.846	1	
Number of enterprises selling food products	0.8	0.901	0.978	0.895	1

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

The close relationships between enterprises in the agricultural production sectors indicate the presence of a substantial factor that affects the development of the ecosystem in general. Paired correlation coefficients between changes in the number of enterprises

and the parameters of the main factors discussed above in agriculture indicate a stable direct relationship between changes in the quantity, changes in the cost of products sold and the financial results of the sector's enterprises (Table 8).

Table 8. Correlation matrix of interdependence of activity parameters of enterprises in the agricultural sector

	<i>Number of enterprises</i>	<i>Number of employees</i>	<i>Sales volume</i>	<i>Financial outcome</i>	<i>Value of fixed and intangible assets</i>
<i>Number of enterprises</i>	1				
<i>Number of employees</i>	0.267	1			
<i>Sales volume</i>	0.813	0.621	1		
<i>Financial outcome</i>	0.756	0.574	0.941	1	
<i>Value of fixed and intangible assets</i>	-0.022	0.404	0.341	0.462	1

Source: calculated per data of Official website of the State Statistics Service of Ukraine (n.d.)

This confirms the above thesis about the predominant value of income from sales of products among the factors that determine the life of agricultural enterprises. It is believed that the profitability factor (financial results) is derived from the volume of products sold, so this

study can be abstracted from it. Income from the sale of agricultural products as a primary link in the food chain has a cumulative effect on the functioning of enterprises in the ecosystem of agricultural entrepreneurship in general (Table 9).

Table 9. Correlation matrix of interdependence of enterprise activity parameters by ecosystem sectors

	<i>Number of enterprises</i>	<i>Number of employees</i>	<i>Sales volume</i>	<i>Financial outcome</i>	<i>Value of fixed and intangible assets</i>	<i>Sales volume in agriculture</i>
<i>Food production enterprises</i>						
<i>Number of enterprises</i>	1					
<i>Number of employees</i>	0.606	1				
<i>Sales volume</i>	0.674	0.853	1			
<i>Financial outcome</i>	0.561	0.494	0.669	1		
<i>Value of fixed and intangible assets</i>	0.635	-0.187	-0.018	0.233697	1	
<i>Sales volume in agriculture</i>	0.906	0.615	0.838	0.660	0.471	1
<i>Enterprises in production and trade of material resources for agriculture</i>						
<i>Number of enterprises</i>	1					
<i>Number of employees</i>	0.247	1				
<i>Sales volume</i>	0.233	0.667	1			
<i>Financial outcome</i>	0.410	0.610	0.883	1		
<i>Value of fixed and intangible assets</i>	0.895	0.555	0.492	0.659	1	
<i>Sales volume in agriculture</i>	0.752	0.534	0.649	0.846	0.908	1
<i>Enterprises trading agricultural products</i>						
<i>Number of enterprises</i>	1					
<i>Number of employees</i>	0.572	1				
<i>Sales volume</i>	0.703	0.460	1			
<i>Financial outcome</i>	0.162	0.431	0.522	1		
<i>Value of fixed and intangible assets</i>	0.272	0.569	0.276	0.461	1	
<i>Sales volume in agriculture</i>	0.649	0.274	0.819	0.621	0.002	1
<i>Enterprises trading food industry products</i>						
<i>Number of enterprises</i>	1					
<i>Number of employees</i>	0.396	1				
<i>Sales volume</i>	0.560	0.714	1			
<i>Financial outcome</i>	0.189	0.136	0.114	1		
<i>Value of fixed and intangible assets</i>	0.024	-0.148	0.079	-0.356	1	
<i>Sales volume in agriculture</i>	0.730	0.552	0.763	0.406	0.297	1

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.)

Agriculture produces a raw material base for the functioning of processing and trade economic activities and generates demand for activities related to the production and supply of material resources for the needs of the industry. Therefore, the influence of this factor is stronger than that of endogenous factors for sectors.

Thus, a comprehensive analysis of the parameters of the functioning of the entrepreneurial ecosystem allowed formulating the thesis about the presence at the national level of the business community of agricultural sector subjects and related industries that are not connected by a clear hierarchical structure, but are connected by a chain of production, processing and promotion of agricultural products, which allows considering them together as an ecosystem of the agricultural sector. Between the parameters of activity of enterprises related to different sectors of the ecosystem of agricultural entrepreneurship, a close relationship with the allocation of income from the sale of agricultural products is observed as the main factor that produces a cumulative effect on the functioning of enterprises in the ecosystem of agricultural entrepreneurship in general.

The objectivity of these statements is confirmed in relevant theoretical studies that form the methodology of the ecosystem approach and practical research devoted to the problems of the functioning of agri-food industries in wartime conditions.

When reviewing the entrepreneurial ecosystem as a theoretical concept, its characteristics, given by R. Röntynen (2024), are considered to be appropriate: complexity; self-organisation; dynamism; interconnection and coevolution; collaboration, collaborative creativity and stakeholder engagement; the presence of added value that is generated in the ecosystem and justifies its existence. Based on the results of an empirical study, this list can be supplemented with a sign of sustainability – as the ability of an ecosystem to return to the established development trajectory, disrupted due to the impact of crisis phenomena. Thus, the dynamics of the volume of products sold are expressed in dollar terms (to eliminate the inflationary factor) – one of the main system parameters that formalises the flows of output products has a wavy appearance (Fig. 3). After a substantial decrease in the volume of sales of the first period of armed aggression in 2014-2015, all links restored sales volumes inclusive to record figures in 2021. The acute phase of the war in 2022 led to a rapid drop in this indicator, but in 2023 the volume of sales was increased. The restoration of ecosystem parameters is achieved, among other things, through a unique combination of large and small forms of doing business in the Ukrainian agricultural business, of which the former has wide opportunities for expanded financing of activities, and small entrepreneurs demonstrate a substantial level of flexibility and adaptability in adverse conditions.

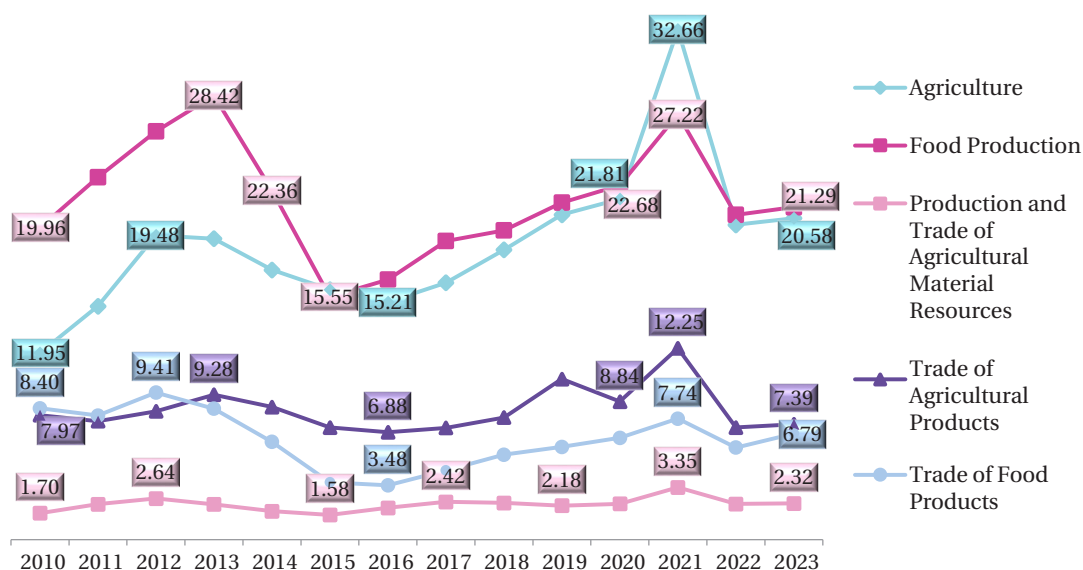


Figure 3. Dynamics of sales volumes of entrepreneurial formations in Ukraine (agricultural activities), billion US dollars

Source: compiled by the authors

The obtained empirical results regarding the stable nature of the dynamics of changes in sales volumes and the substantial impact of sales in agriculture allow expanding the hypothesis proposed by R. Röntynen (2024) about the existence of a coordination locus in entrepreneurial systems – “a central agent that unites all participants and provides the necessary tools for creating and distributing value” as a guarantor of the institutional sustainability of the system. It is proposed to extend these properties not only to the subjects (agents) of the system but also to its

elements. Indeed, the essential importance of Ukrainian agricultural products on world markets makes the chain of their production, processing and promotion a centre around which entrepreneurs coordinate their efforts, motivated by the goal of making a profit. However, the proof of this hypothesis and the determination of the specifics of the sale of agricultural products, in particular, in wartime conditions, should be the subject of a separate study.

The use of the ecosystem approach opens up wide opportunities for further research of the state and pros-

pects for the development of entrepreneurship in the agricultural production sector. O. Vigren (2024), based on the processing of 42 publications by methods of qualitative analysis, identifies seven conceptual areas of ecosystem research: ecosystems as local formations; ecosystems that were formed around technologies or chains of value creation; using the concepts of “ecosystem” to understand the processes of transformation of the industry; identifying the mechanisms for creating added value through synergistic interaction of ecosystem subjects; determining the logic and conditions of ecosystem development; ways of forming ecosystems as purposeful projects; outlining the role characteristics of typed groups of ecosystem subjects (agents) and ways to interact between them.

In a conceptual context, a study by X. Zhang *et al.* (2024) based on bibliometric analysis, where researchers distinguish between entrepreneurial and business ecosystems. The first concept provides for the concentration of research interest on forming effective entrepreneurial systems as a result of combining entrepreneurial initiatives with available resources, cultural characteristics, and social networks of specific territorial communities. The second focuses on cases of deliberate and intentional development of a community of producers, suppliers, consumers, and other stakeholders who collectively develop their capabilities in implementing the direction outlined by the company(s) leader.

All these concepts have a substantial potential for research in the context of solving relevant issues of the functioning of agricultural entrepreneurship. In their development, it is worth noting L. Blagodyr's (2022) assertion regarding the institutional conditioning of intentional entrepreneurial ecosystem development in light of the global trend towards digitalisation; however, much depends on local initiatives and regional traditions.

I. Chernii & O. Panukhnyk (2024) should also be agreed with, since the activity of subjects of the business environment in modern conditions of uncertainty is characterised by instability, and primarily the inconsistency of processes that occur. Within the subjects themselves, the question of the need for a more detailed analysis of the characteristic features of digital business ecosystems that are being formed in Ukraine at the local level arises (Shveda *et al.*, 2024). The proposed methodology for structuring the entrepreneurial ecosystem is a starting point for the development of further research on the basics and features of its functioning in the agricultural sector of the Ukrainian economy.

► Conclusions

This study examined the possibilities of applying an ecosystem approach to assessing the state and trends in the development of the agricultural sector of the Ukrainian economy in wartime conditions. In accordance with this, its purpose and objectives were formulated and a hypothesis was put forward regarding the sector's

resistance to destructive external influences. Based on the generalisation of scientific publications on the problems of the ecosystem approach, its prospects for conceptualising the mechanisms of functioning and development of the agricultural sector as an economic community of independent enterprises without a clearly defined hierarchy in the context of crisis phenomena of martial law are clarified.

The investigation of the dynamics of the main parameters of the entrepreneurial ecosystem of the agricultural sector, formalised by aggregated groups of economic activities, indicates its relative stability. After a substantial reduction in the number and volume of products sold in all parts of the ecosystem, caused by the socio-economic shock from the beginning of the acute phase of military aggression in 2022, in 2023 the values of these parameters stabilised and began to grow. The correlation analysis showed a close relationship between the parameters of activity of enterprises belonging to different sectors of the ecosystem of agricultural entrepreneurship with the allocation of income from the sale of agricultural products as the main factor that produces a cumulative effect on the functioning of enterprises of the ecosystem of agricultural entrepreneurship in general.

The obtained empirical results on the sustainable nature of the dynamics of changes in sales volumes and the substantial impact of sales in agriculture on the functioning of other parts of the entrepreneurial ecosystem of the agricultural sector allow determining production, processing, and promotion of agricultural products as the central element around which entrepreneurs of the agricultural sector coordinate their efforts. This makes the definition of the specific features of the sale of agricultural products in wartime the subject of a separate study in the context of assessing the impact of military aggression on the development of agricultural entrepreneurship. As for further research on entrepreneurial ecosystems, the presented methodological approach to their structuring is the starting point for the development of further investigation on the basics and features of its functioning in the agricultural sector of the Ukrainian economy.

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► Conflict of interest

None.

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Розвиток підприємницької екосистеми аграрного сектору України в умовах впливу воєнного часу

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► **Анотація.** Підприємства, що здійснюють та забезпечують виробництво сільськогосподарської продукції, її переробку та просування на внутрішні та зовнішні ринки об'єктивно функціонують в тісному взаємозв'язку, що забезпечує певну економію трансакційних витрат, але й робить весь ланцюг вразливим до негативного впливу зовнішніх чинників. Метою дослідження було здійснити економічну оцінку тенденцій її розвитку в умовах впливу воєнного часу. Теоретично обґрунтовано її економічну сутність, структуру та функціональні характеристики, а саме: визначено особливості розвитку аграрного сектору України, характер його трансформацій під впливом різнонаправлених змін в умовах впливу воєнного часу. Встановлено й методично обґрунтовано взаємозалежність результативності, економічної ефективності підприємств, що відносяться до секторів екосистеми. Систематизовано і актуалізовано тенденції утворення результатів господарювання в деструктивному інституційному середовищі. Методично опрацьовано проблематику сучасних тенденцій розвитку екосистеми та здійснено оцінку: структурних змін у складі підприємницьких формувань, зайнятості населення у підприємницьких формуваннях; змін матеріальної бази, обсягу реалізованої продукції та прибутковості підприємств екосистеми. Оцінка проведена за виділеними етапами збройної агресії в розрізі секторів екосистеми: «сільське господарство»; «виробництво харчових продуктів»; «виробництво та торгівля матеріальними ресурсами для сільського господарства»; «торгівля продукцією сільського господарства»; «торгівля харчовою продукцією» та за основними розмірними групами великі та середні – малі підприємства. Доведено високу тісноту зв'язку між параметрами діяльності підприємств екосистеми аграрного сектору, що має системний характер та виокремлено чинник доходу від реалізації сільськогосподарської продукції як найбільш значущого для її функціонування. Отримані результати роблять внесок в розуміння закономірностей взаємозалежності розмірів і результативності господарювання підприємств аграрної екосистеми як цілісного утворення в умовах воєнного часу, що визначає її спроможність досягти критерію стійкості, конкурентоспроможності, а головне – збереження кожного конкретного підприємства – як економічно, так і фізично

► **Ключові слова:** підприємництво; бізнес-екосистема; господарські структури; економічна діяльність; інституційна структура; сільське господарство



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Legal and economic issues of geographical indications for agricultural products in Poland and Ukraine

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► **Abstract.** Geographical indications are beginning to make an important place in the agri-food products market, as they ensure the recognition of products on the world market, therefore the issues of ensuring their protection and effective use are relevant. The main goal of the study was to conduct a comparative statistical analysis of legal and economic issues of geographical indications of food products in the agricultural sector of Poland and Ukraine. The research used the methods of descriptive statistics, the method of comparative analysis, the graphic method, the monographic approach, and the abstract-logical method. The structure of agricultural market output of European Union countries, Poland, and Ukraine was investigated. It was established that Ukraine is dominated by the export of plant products, while Poland and the European Union countries focus on goods with added value. An analysis of geographical indications in force by product category and geographical indications in force by legal means was carried out. Geographical indications registered in Poland and Ukraine for specific types of products were examined. It was established that fresh fruits, vegetables, and cereals predominate among the categories of registered geographical indications in Poland, while wine and mineral water are the most common groups of geographical indications registered in Ukraine. The approaches to the interpretation of the category of geographical indication in the European Union, Poland and Ukraine in accordance with the norms of the current legal acts have been analysed, and the main differences have been established. An analysis of the main common and different approaches to the regulation of geographical indications in the European Union, Poland and Ukraine in accordance with the regulatory framework was carried out. It has been established that in Poland there are different registration procedures and authorities for goods of industrial property and separately for agricultural goods. In the European Union, there is a separate regulation on geographical indications of alcohol. In Ukraine, there is a separate procedure for the registration of only alcoholic beverages, and there is no separate procedure for agricultural products. The results of the study are of practical importance for regulatory bodies of Ukraine in the direction of innovation development and expansion of intellectual property protection procedures in the agricultural sector

► **Keywords:** intellectual property; European integration; international trade; regulations; sustainable development

► Introduction

In the conditions of today's globalization processes, geographic indicators of various goods have become an indispensable attribute of sustainable development. The formation of a brand-oriented global economy is an evolutionary process that requires management in order to

increase its effectiveness. G. Studinska (2020) emphasises that branding, in turn, significantly strengthens the scope and deepens the consequences of the impact of globalisation, both economic and political, cultural, social processes on the planet, because the development of brands of

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goods and services involves maximising promotion on the world market of goods and services, which is provided by technical, technological, creative, marketing advantages of the respective producers. However, the author does not focus his attention on the role of brands in Ukraine in the context of the globalisation of trade.

A number of Ukrainian scientists researched and described in detail the brand strategy in the management of enterprises using the example of the border region, carried out an analysis of the management of European integration business processes at enterprises and ensuring their competitiveness on the basis of branding technologies (Vdovichen, 2023). However, this work does not reveal problematic issues of Ukraine's European integration in the field of geographical indications and the development of a common agrarian policy.

I. Bezhenar (2024) in scientific work analyse challenges and opportunities for the development of agro-food products and the creation of brands. The author reveals in detail the peculiarities of Ukrainian GI, however, there is no comparative analysis of the legal framework of Ukraine and EU countries.

I. Martyniuk (2024) in research concentrates its attention on the peculiarities of legal protection of geographical indications and trademarks, their differences. However, the researcher does not focus his attention on European integration processes, but concentrates only on the regulatory and legal field of Ukraine.

To join the EU, countries must adopt EU legislation. The European Commission's report on Ukraine determined that Ukraine is a "moderately prepared" country in the field of agri-food safety, phytosanitary and veterinary norms and standards (Ukrainian agriculture..., 2024). In the context of this problem, N. Stoliarchuk *et al.* (2021) emphasises the importance of analysing the factors of agricultural production and finding new ways and opportunities to increase farmers' incomes and increase labour productivity in accordance with the UN Sustainable Development Goals (SDGs). However, this article does not specifically address the role of GI.

In Ukraine, the process of adapting national legislation to EU requirements in the field of innovation and intellectual property was started decades ago. According to D. Rdzanek (2021) research considering the territorial, climatic and historical proximity of Poland and Ukraine, as well as the important role of the agricultural industry in both countries, the successful experience of Poland in the direction of European integration can be an example for Ukraine. In the study, the author examines the implementation of the Common Agricultural Policy mechanisms of the European Union in Poland in the context of the European integration of Ukraine. However, GI are not specifically considered in this article. A number of Ukrainian scientists in a collective monogamy consider general approaches to the European integration of the agricultural sector of Ukraine to the EU, especially in terms of land reform, development of rural areas and the use of subsidies for farmers, but the authors do not consider the direction of innovation and intellectual property (Wigier & Kowalski, 2018).

However, despite the significant attention of scholars to geographical indications and branding in the context

of European integration and sustainable development, their role in Ukraine is insufficiently researched. This determined the actual purpose of the study, which consists in study the regulatory and legal field of Ukraine, Poland, and the EU in the context of GI, their statistical analysis and providing recommendations for improving the Ukrainian legislation in the part of the European integration processes of GI. The main tasks of the research are to carry out a detailed analysis of registered geographical indications of Poland and Ukraine by product categories and territory; analyse the approaches to the interpretation of the geographical indication category in the EU, Poland and Ukraine; to conduct a comparative analysis of legislative acts of the EU, Poland and Ukraine regarding the registration and use of GI agricultural products.

► Materials and methods

The research was carried out based on the National Scientific Centre "Institute of Agrarian Economics" in Kyiv, Ukraine and the Adam Mickiewicz University in Poznań, Poland in 2023. Statistical data for the years 2019-2023 were taken for the study. The information base of the research is made up of current legal acts of Ukraine and Poland, EU Regulations, scientific publications of scientists, materials from Internet resources, own author's research and observations, other market information. To obtain data about GI registration in the EU according to EU procedures was used: Official website of the European Commission Statistics (n.d.), Official website of the World Intellectual Property Organization (n.d.) and eAmbrosia – the EU geographical indications register (n.d.). To obtain information on the protection of GI according to the national procedures of Ukraine was used the Official website of the State Statistics Service of Ukraine (n.d.) and Information from the State Register of Ukraine of place names and geographical indications of goods and rights to use registered qualified designations of origin of goods (n.d.). To obtain information on the protection of GI according to the national procedures of Poland was used Official website of the Statistics Poland (n.d.).

To compare the situation in Ukraine and Poland, various statistical methods were used, which allow detailed analysis and interpretation of data. The main research methods were descriptive statistics, which helped to get a general idea of the situation in both countries, in particular through such indicators as average values and frequency distributions. Index analysis was also used. The method of comparative analysis was used to determine the differences in the regulation of geographical indications in Poland and Ukraine. The graphic method was used to visualise the results of the analysis of the structure of the agricultural market of EU countries, Poland and Ukraine, as well as for geographical indications registered in Poland and Ukraine by types of products. The methods of descriptive statistics, namely the grouping of data and percentage indicators, were applied in the analysis of current geographical indications by product categories and by in force by legal means. The monographic approach made it possible to determine the difference in the registration systems of geographical indications between Poland and Ukraine. For this purpose, the regulatory legal acts of the EU, Poland and Ukraine in the field of registration of

geographical indications were analysed. The abstract-logical method was used to generalise the provisions considered in the scientific works of various authors and normative-legal documents and compare them with the goals of the Common Agrarian Policy. This made it possible to determine whether the European integration processes of Ukraine in the field of geographical indications correspond to the general plan of European integration and the Common Agrarian Policy.

► Results and Discussion

In May 2024, the Parliament of European Union adopted a new regulation on GI specifically for agricultural goods and alcoholic products (Regulation No. 2024/1143..., 2024). This legally correct act should contribute to the development of agricultural trade, the development territories in the village area, the achievement of the declared goals of sustainable development, the defence of the rights of producers, the protection of product quality, and it also combines all the procedures that were previously in many different documents. The new principles should simplify the procedure for registering GI. According to the regulation, the role of the Intellectual Property Office of the European Union will increase. Also, the new law is aimed at supporting the production of traditional and original, craft and organic agricultural goods, which in turn requires better protection of such GI and control over counterfeits. This is an important step in maintaining product quality and developing regional GIs.

Modern EU policy has begun to consider in detail the role of GI in the economic development of small enterprises at the local level and in cooperative associations. According to A. Suchon (2022), the current trajectory of agricultural cooperatives aligns with EU policy developments. This is linked to various factors such as enhancing the competitiveness of agricultural producers, safeguarding regional products, fostering the social economy, addressing energy and environmental concerns, and promoting processing activities. This view is true, but the relationship between geographical indications, agricultural cooperatives and the Common Agricultural Policy would be worth looking into in more detail.

D. Curzi & M. Huysmans (2022) in scientific work concentrates on the fight against the imitation of the origin of goods. For products that are at the stage of registration or for original products with an indication of the source of goods fighting imitations of their product, the period of protection and extension of the protection of GI may be longer than usual. It is also recommended to indicate the list of GIs in trade agreements, which will contribute to more efficient and transparent exports between countries. This research is quite relevant, but the authors also do not take into account the regulatory and economic aspects of the Common Agrarian Policy.

According to L. Faria-Silva & K.G. Baião (2023) the protection of products of intellectual activity contributes to the greening of production, the development of new technologies that are safe for food products, which in turn meet global standards. Therefore, innovations have a main role in the development of world trade. This statement is not so relevant, since the manufactured products must be ecological and meet product quality standards, regardless

of whether the enterprise uses GI. According to I. Bezhehar & L. Malik (2015), F. Sgroi *et al.* (2022), manufacturers who are committed to a long-term export strategy must have a registered GI in their business. This creation is true, but the authors should also focus on European integration processes and common agricultural policy.

S. Stranieri *et al.* (2023) proves that an important direction of registration of geographical indications is also the promotion of innovative products in regions with a low level of economy. The authors suggest that GIs primarily foster the creation of a competitive environment but do not necessarily drive the adoption of innovative technological processes. According to a study by P. Vimalnath *et al.* (2023), when creating a business development strategy, companies are increasingly based on the principles of sharing intellectual property, connecting them to the SDGs. The opinion of the author is correct; however, he considers the strategy of intellectual property as a whole, without paying enough attention to GI.

P. Swagemakers *et al.* (2021) in the studies suggest that the quality of agri-food products and the advancement of farm sustainability are closely linked to brand development. The food system relies on the interconnectedness of small producers, the retail network, and consumers. This statement is partly true, as the authors reveal the relationship between brands and sustainable development of agricultural practices, but do not reveal the essence of regulatory and legal regulation.

D. Salpina & F. Pagliacci (2022) states that the name of the GI is always associated with the geographical place of production of the product. However, there are already fears among scientists that climate change will bring about a change in the usual geographical location of the cultivation of agro-food products. This is especially relevant for the cultivation of vineyards and the production of wine and related alcoholic beverages. The authors conducted a rather interesting and significant study that reflects the role of climate change in the spread of local GIs, this study is quite relevant and share the opinion of the researchers.

O. Peredriy *et al.* (2024) determines advantages and disadvantages in the process of registration and use of GI in Ukraine and the EU. The opinion of the authors is relevant; however, the author does not focus his attention specifically on the legal and procedural aspects of GI registration. T. Chernukha & A. Hovorovska (2021) on the example of the Ukrainian registered GI "Melitopol cherry", they conduct the effectiveness of the use of local GIs and describe the strategy of effective use of GIs in the area. This research is quite thorough and relevant; however, the study is related to the analysis of indicators at the local level and does not include export strategies and European integration needs. K. Poetschki *et al.* (2021) analyse the impact of local GIs on the efficiency of local farmers in the EU, but the main products are wine and olives. The impact of GI on the activities of farms was assessed quite positively. This publication is also very relevant, but the authors did not assess the relationship between the effectiveness of GI application at the local level and EU policy.

Ch. Beaucillon (2023) in the study analyses the EU's policy on world trade, analysing the Concept of Strategic Autonomy, which is the basis of the European Parliament. However, the paper does not examine the impact of this

theory on the Common Agricultural Policy and trade in agricultural goods.

GI help producers of agri-food products to distinguish their products both on the domestic and foreign markets, as well as to protect their products from counterfeiting. The quality of manufactured goods is important both for the food security of each country and for the food security of the world. Poland and Ukraine have a similar climate, a large area of agricultural land, and both are significant producers and exporters of agricultural

products. In 2021, Ukraine exported about 40% of sunflower oil from the world export volume, more than 10% of corn and about 10% of barley, as well as about 10% of wheat and rapeseed from the world export (Matvieiev, 2023). This analysis is quite relevant, as it confirms the importance of Ukraine in the EU agro-food market. Figure 1 presents the results of analysis of the export of agri-food products by the EU countries, Poland and Ukraine, namely: live animals and live-stock products, plant products, ready food products.

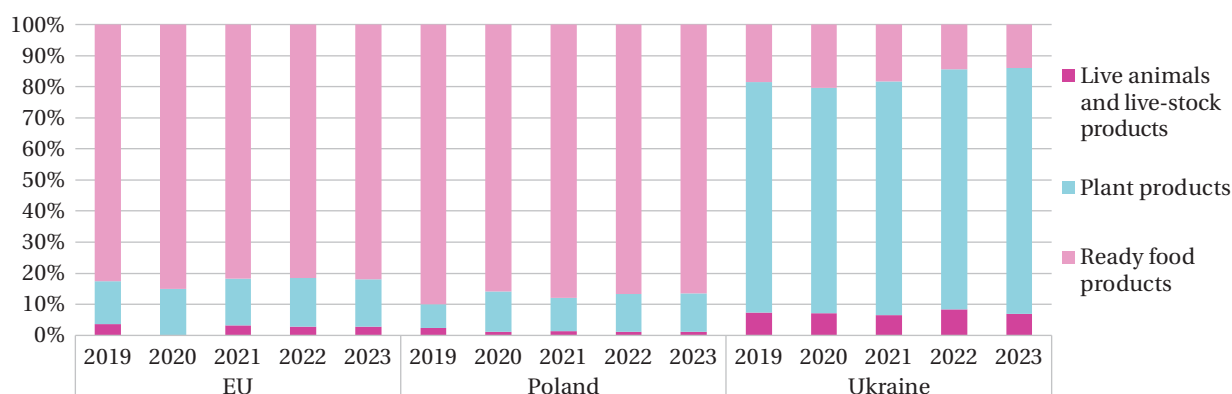


Figure 1. Structure of agricultural market output of EU Countries, Poland and Ukraine thousands USD

Source: author's research on the basis by data of the Official website of the European Commission Statistics (n.d.); Official website of the State Statistics Service of Ukraine (n.d.) and Official website of the Statistics Poland (n.d.)

Ukraine is dominated by the export of plant products, and in Poland and the EU countries, agro-food products, i.e. goods with added value (Smolii & Mostoviak). Accordingly, this affects the need for the number of geographical indications, which is higher for commercial

products. The Table 1 analyse the number of registered Geographical indications in force by product category in Poland and Ukraine as of 2023 based on data The World Intellectual Property Organization (WIPO) from various procedures.

Table 1. Geographical indications in force by product category, as of December 2023

product	Poland		Ukraine	
	pcs	%	pcs	%
Agricultural products and foodstuffs	1,909	36.9	833	26.7
Handicrafts	1	0	2	0.1
Wines and spirits	3,267	63.1	2,289	73.3

Source: compiled by the authors based on the Official website of the World Intellectual Property Organization (n.d.)

Among the categories of geographical indications both in Poland and in Ukraine, wines and spirits prevail. Agro-food products are on the second position. The

Table 2 analyse the number of registered Geographical indications in force by legal means in Poland and Ukraine as of 2023 based on data The WIPO from various procedures.

Table 2. Geographical indications in force by legal means, as of December 2023

indications	Poland		Ukraine	
	pcs	%	pcs	%
Agreements	1,779	34.4	3,091	98.9
Sui generis	1	0	33	1.1
Regional system	3,396	65.6	-	-
Lisbon system	1	0	-	-

Source: compiled by the authors based on the Official website of the World Intellectual Property Organization (n.d.)

Both in Poland and in Ukraine geographical indications are mainly registered and concluded of agreements. Almost no registration is carried out under the

Lisbon system. The Figure 2 shows the complete list of geographical indications of Poland as of 2024, registered in Poland.

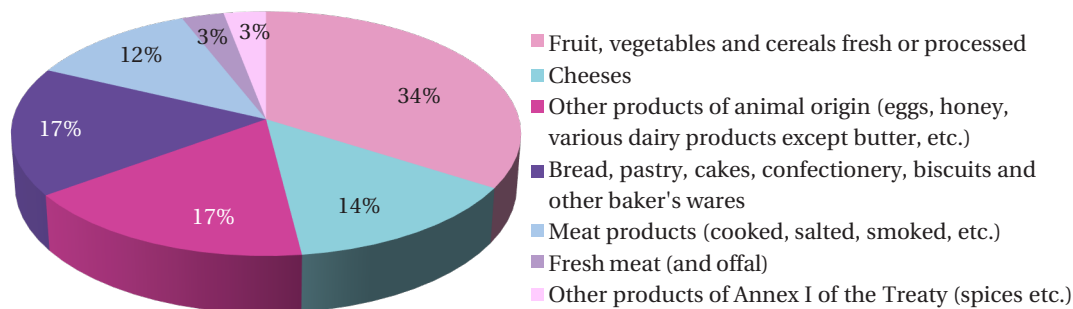


Figure 2. Polish geographical indications registered in Poland for the type of products

Source: compiled by the authors based on the EU geographical indications register (eAmbrosia) (n.d.)

Among the groups of commercial products for which geographical indications are registered in Poland, Fruit, vegetables and cereals fresh or processed prevails. The main region of origin of most geographical indications in Poland is the Malopolski region. The Figure 3 shows the complete list of geographical indications of Ukraine as of 2024, registered in Ukraine. Among the groups of commercial products for which geographical indications are registered in Ukraine is Wine and Mineral Water. The main region of origin of most geographical indications in Ukraine is Crimea. In addition to EU regulations, Poland also complies with national legislation in its economic activities. The regulation of activities related to geographical

indications is governed by the Law on Registration and Protection of Names of Places of Origin, GI, and Guaranteed Traditional Features for Agricultural Products, enacted on March 9, 2023 (Act of Poland..., 2023). This also includes agricultural products, food products and alcohol. In Ukraine, the main normative acts regulating the registration of geographical indications are the Law of Ukraine dated June 16, 1999 No. 752-XIV (Law of Ukraine No. 752-XIV..., 1999) and the Law of Ukraine dated December 1, 2022 No. 2800-IX (Law of Ukraine No. 2800-IX..., 2022). Consideration the rules of registration and safeguard of GI in Poland and Ukraine, as well as determine the differences and similarities of the procedures (Table 3).

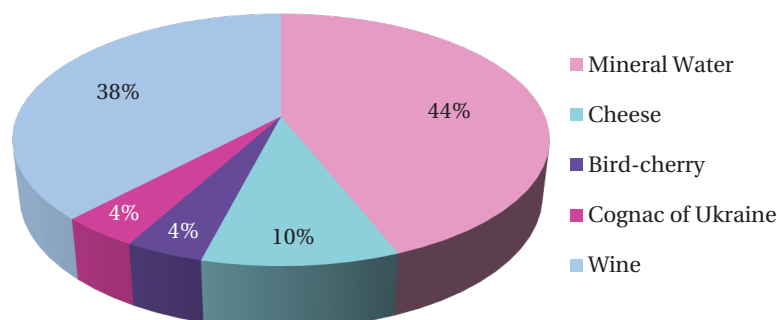


Figure 3. Ukrainian geographical indications registered in Ukraine

Source: compiled by the authors based on the Information from the State Register of Ukraine of place names and geographical indications of goods and rights to use registered qualified designations of origin of goods (QDO) (n.d.)

Table 3. Approaches to the interpretation of the geographical indication category in the EU, Poland and Ukraine

No.	Country	Regulation	Interpretation
1	EU	Regulation (EU) 2024/1143 of 11 April 2024 (Regulation No. 2024/1143..., 2024)	▶ the name; ▶ product detailed characteristics; ▶ indication of the area of production; ▶ description of the technology; ▶ characteristics of packaging, processing, storage and transportation of the product; ▶ impact on sustainable development goals.
2	Poland	ACT of March 9, 2023 (Act of Poland..., 2023)	▶ agricultural product and foodstuff: ▶ wine; ▶ spirit drink
		ACT of 30 June 2000 (Act of Poland..., 2000)	a verbal description that in a certain way indicates the name of the place, which allows you to determine that the product really comes from a given territory, and that the given quality properties of the product can only be when it originates from a given territory

Table 3, Continued

No.	Country	Regulation	Interpretation
3	Ukraine	Law of June 16, 1999 No. 752-XIV (Law of Ukraine No. 752-XIV..., 1999) Law of September 20, 2019 No 123-IX (Law of Ukraine No. 123-IX..., 2019)	the name of the region where the product comes from, which imparts specific marketing and production characteristics to the product. This applies to the territory even if the goods underwent only one specific stage (for example, cultivation), and not the entire process of giving the product the properties of a product ready for sale
		Law of December 1, 2022, No. 2800-IX (Law of Ukraine No. 2800-IX..., 2022)	the name that identifies the product and the territory of its origin, cultivation or processing, which gives this product these unsurpassed properties inherent only to this product

Source: author's research on the basis of EU, Poland and Ukrainian laws

In Poland, there are two systems of providing geographic values. One for industrial property goods, the other for agricultural goods. They are regulated by different departments, different legal acts and submitted according to different applications. On June 23, 2022, a significant event in Ukraine's history occurred when the European Parliament passed a resolution granting Ukraine candidate status for membership in the EU

(EP resolution..., 2022). This means that Ukraine must switch to European standards in all areas, including the agricultural sector and intellectual and innovation function. A good example of European integration is the Republic of Poland, which, like Ukraine, was a post-Soviet country. Therefore, it is worth investigating the approaches of Polish integration into the European space (Table 4).

Table 4. Differences in the regulation of geographical indications in Poland and Ukraine

No.	Country	Poland	Ukraine
1	Registration procedure	The procedures are conducted in two stages: the first must be registered within the territory of the member state, and the second at the European Commission level. The relevant authorities are obliged to check the application and give it to the European Commission. To sell goods in another country, it is necessary to register a geographical indication in that country (Association Agreement..., 2014; Regulation No. 2019/1753..., 2019; Regulation No. 1308/2013..., 2013).	Procedures for registration of names as protected geographical indications take place in one stage, by submitting an application to the relevant body of Ukraine. To sell goods in another country, it is necessary to register a geographical indication in that country.
2.	Registration for different groups of goods	National law of March 9, 2023 (Act of Poland..., 2023), Industrial Property Law of 30 June 2000 (Act of Poland..., 2000) as well as Regulation (EU) 2024/1143 of 11 April 2024 (Regulation No. 024/1143..., 2024), Regulation of the European Parliament No. 2017/625 (Regulation No. 2017/625..., 2017).	For alcoholic beverages: The law of Ukraine from December 1, 2022, No. 2800-IX (Law of Ukraine No. 2800-IX..., 2022). For all other goods (both industrial and agricultural): The law of Ukraine dated June 16, 1999 No. 752-XIV (Law of Ukraine No. 752-XIV..., 1999).
3	Responsible institution	► EUIPO ► WIPO ► Patent Office of the Republic of Poland ► Ministry of Agriculture and Rural Development ► European Commission through the Ministry of Agriculture and Rural Development	► The National Intellectual Property Authority (NIPO), whose functions are performed by the state organization UKRNOIVI ► EUIPO ► WIPO
4	Security document	Certificate (Regulation No. 2024/1143..., 2024; Act of Poland..., 2023)	Certificate (Law of Ukraine No. 752-XIV..., 1999)
5	The validity period of the geographical indication certificate	not limited (Regulation No. 2024/1143..., 2024; Act of Poland..., 2023)	10 years (Law of Ukraine No. 752-XIV..., 1999)

Table 4, Continued

No.	Country	Poland	Ukraine
6	Requirements for the protection	▶ the name of the GI subject to protection; ▶ detailed characteristics of the product itself; ▶ indication of the territory of goods and evidence of the originality of its origin; ▶ the technology of obtaining or manufacturing the product; ▶ characteristics of packaging, processing, storage and transportation of the product. Also, an important element of the product description is sustainability of the GI products. (Regulation No. 2024/1143..., 2024; Act of Poland..., 2023).	The name of a historical territory can be a GI name if the ingredients of the product originate from that territory, even if the finished product is already produced in another region. However, this applies only to the breeding of farm animals and their products (Law of Ukraine No. 752-XIV..., 1999).
7.	The right to register a geographical indication	Only a certain group of producers can register a GI in a certain territory. Producers can exist in the form of a cooperative, joint organization, association. In some cases, security must be confirmed by the local authorities. If the producers come from a cross-border territory, such an application can be submitted by groups of producers from different countries (Regulation No. 2024/1143..., 2024; Act of Poland..., 2023; Regulation No. 2019/787..., 2019).	A GI can be registered by a group of producers and a feature of the product, its specific qualities are determined by this place. A GI can also be registered by one natural person or one manufacturer. This is possible if he is the only producer in a given geographical area and the territory itself is significantly different from other geographical areas, which determines the features of the finished product (Law of Ukraine No. 752-XIV..., 1999; Law of Ukraine No. 2800-IX..., 2022).

Source: author's research on the basis of EU, Poland and Ukrainian laws (n.d.)

Ukraine's adoption of the Association Agreement requires the country to improve its requirements for the protection, registration and implementation of rights for all intellectual property objects, including geographical indications. Ukraine, as a constitutional country of the European space, is open to international cooperation in accordance with the requirements of foreign policy. However, this cooperation should be based on equality, not disrupt the core principles of the state's internal policies, and should proceed on mutually beneficial terms. In order to guarantee the safety of inventive activity within the framework of foreign economic activity, in 2020 Ukraine adopted the Law No. 816-IX dated July 21, 2020 (Law of Ukraine No. 816-IX..., 2020). And already in 2023, a corresponding Memorandum was signed between Ukraine and the European institution EUIPO in the field of innovation (EU-Ukraine cooperation..., 2023).

Europe aims to establish clear regulations regarding the use of GI names. According to several legal acts adopted within the EU and in countries like Ukraine, it will be prohibited to use certain GI names without proper authorization starting in 2026: "champagne", "cognac", "feta", "parmesan", "roquefort" (Association Agreement..., 2014). This is a key principle in the operation of the European market regarding intellectual property and the protection of the original producer. Ukraine, seeking to integrate into the European space, is currently trying to harmonise national legislation with EU requirements as much as possible. Significant progress has been achieved in this direction as of today.

At the same time, in order to improve the quality of agro-food products and strengthen international trade, more attention should be paid to the criteria for agricultural products and goods. The digitization of applications, registers and reporting information on registered geographical indications also needs improvement.

► Conclusions

GI contribute positively to the economic growth of farms and the nation overall. Exports of Ukraine to EU countries have increased in recent years, including thanks to the increase in the number of registered GIs. Among the categories registered GI of Poland, Fruit, vegetables and cereals fresh prevail. In Ukraine, among the groups of registered GI, wine and mineral water predominate. Registration procedures in both countries are also different. Poland must first register the product in its country according to the national procedure, and then in the EU. If Poland intends to sell its products outside the EU, it must register them in each non-EU country it exports to. In Poland, there are different procedures and registration bodies for goods of industrial property and separately for agricultural goods. In the EU, there is a separate regulation on geographical indications for alcohol. In Ukraine, there is the same registration procedure only for alcoholic beverages, as for agricultural products, there is no separate procedure. Ukraine currently registers geographic indications for goods according to the national procedure, and for export needs, it must register according to the procedure of the country of export. Having compared the acts of the EU, Poland and Ukraine in the

field of GIs, can state that Ukraine has implemented many reforms and brought the legislation in the field of geographical indications as close as possible to EU requirements. The future research prospects involve adapting the EU's Common Agricultural Policy to meet current demands in the field of geographical indications, while considering the specific characteristics of the associated EU member states.

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►Conflict of interest

None.

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Правові та економічні питання географічних зазначень сільськогосподарської продукції в Польщі та Україні

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► **Анотація.** Географічні зазначення починають відігравати важливу роль у торгівлі агропродовольчою продукцією, оскільки забезпечують впізнаваність продукції на світовому ринку, тому питання забезпечення їх охорони та ефективного використання є актуальними. Основною метою статті було провести статистично-порівняльний аналіз правових та економічних питань географічних зазначень харчових продуктів в аграрному секторі Польщі та України. У дослідженні використовувалися методи описової статистики, метод порівняльного аналізу, графічний метод, монографічний підхід, абстрактно-логічний метод. Досліджено структуру продукції сільськогосподарського ринку країн Євросоюзу, Польщі та України, встановлено, що в Україні переважає експорт продукції рослинництва, а в Польщі та країнах Євросоюзу – товарів з доданою вартістю. Проведено аналіз чинних географічних зазначень за категоріями товарів та географічних зазначень, чинних законодавчо. Було досліджено географічні зазначення, зареєстровані в Польщі та Україні для типу продуктів, і встановлено, що серед категорій зареєстрованих географічних зазначень в Польщі переважають свіжі фрукти, овочі та злаки, а серед груп географічних індикацій, зареєстрованих в Україні, переважають вино та мінеральна вода. Проаналізовано підходи до тлумачення категорії географічного зазначення в Євросоюзі, Польщі та Україні відповідно до норм чинних нормативно-правових актів та встановлено основні відмінності. Проведено аналіз основних спільних та відмінних підходів до регулювання географічних зазначень в Євросоюзі, Польщі та Україні відповідно до нормативно-правової бази. Встановлено, що в Польщі існують різні процедури та органи реєстрації для товарів промислової власності та окремо для сільськогосподарських товарів. В Євросоюзі існує окремий регламент щодо географічних зазначень алкоголю. В Україні існує окремий порядок реєстрації лише алкогольних напоїв, а для сільськогосподарської продукції немає. Результати дослідження мають практичне значення для регуляторних органів України у напрямку розвитку інновацій та розширення процедур захисту інтелектуальної власності в агросфері

► **Ключові слова:** інтелектуальна власність; європейська інтеграція; міжнародна торгівля; регулювання; сталий розвиток



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Foreign market entry strategy as a key to the competitiveness of enterprises

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► **Abstract.** The study aimed to highlight the peculiarities of the formation and use of strategies for entering the foreign market by modern business entities, using enterprises in the agrarian sector of the economy as an example. The methods of economic and statistical analysis, including the Wilcoxon statistical method for comparing trends, as well as the scoring method, were used to process the data. The current study identified the peculiarities of the development of the agricultural sector in the European Union countries and Ukraine in particular, focusing on the main challenges and opportunities faced by agricultural enterprises in the context of globalisation. It was found that the development of the agricultural sector depends on access to resources, technological progress and appropriate state support. The importance of introducing innovations and attracting investments to increase the competitiveness of agricultural enterprises was emphasised. The main motives and strategies for their entry into foreign markets were outlined, including: product differentiation strategy, pricing strategy (cost leadership strategy), innovation strategy, expansion into new markets, branding strategy, sustainable development strategy, and localization strategy. The article analysed the agricultural sector of Ukraine and provides an overview of strategies for entering foreign markets of 15 Ukrainian agricultural enterprises, drawing attention to existing problems in infrastructure and logistics. The

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author substantiated the areas of improvement, including investments in modernization, development of logistics networks and improvement of product quality in accordance with international standards, which will help to increase their competitiveness in the global market. The obtained results emphasise the importance of an integrated approach, including product differentiation, price competition and innovation strategies to ensure the competitiveness of agricultural enterprises in the global market, as well as the need to adapt strategies to the specifics of local markets and sustainable development trends

► **Keywords:** agrarian sector of the economy; innovation and investment sustainable development; expansion; export of products; risk diversification; effective management; state support

► Introduction

The development of foreign economic activity is an important area for the successful integration of modern enterprises into the global economy. For the effective development of any country's economy, strategic entry into international markets is becoming one of the main tools for ensuring competitiveness and improving economic positions on the global stage. Expanding the geography of sales, optimizing supply chains and implementing innovative strategies are essential to improve the success of business entities in the global competition. In the context of the issues under consideration, special attention should be paid to the enterprises of the agricultural sector of the economy, which is able not only to meet the needs of consumers in the domestic market, but also to significantly strengthen the competitiveness and image of the country in foreign markets.

According to the forecasts of the information and analytical agency, the value of gross output in the agricultural market at the end of 2024 will be USD 4.59 trillion, with an expected annual growth of 3.76% to USD 5.52 trillion by 2029. The value of imports in this market is forecast to reach USD 949.7 billion, with an annual growth of 11.54%. In contrast, the value of agricultural exports will reach USD 841.7 billion by the end of 2024, with an expected annual growth of 17.73% (Statista, 2024). These data highlight the importance of strategic access to international markets as a promising condition for ensuring the growth and competitiveness of agricultural enterprises.

In this context, the formation of effective external strategies and the rational use of modern methods of managing foreign economic activity becomes crucial for success. Strategies for entering foreign markets may include diversification of sales markets, expansion of export geography, optimization of logistics processes, and improvement of product quality (Larina, 2019; Munteanu, 2024; Dooranov *et al.*, 2024). In this context, it is important to take into account the specifics of the markets targeted by the enterprise and adapt strategies to the requirements and opportunities of each particular market.

The analysis of literature sources on the use of various strategies for entering foreign markets by agricultural enterprises has revealed a number of main research areas. T. Gagalyuk *et al.* (2022) investigated in their article why Ukraine has become a key player in global agri-food markets. The authors emphasised the importance of adapting the strategies of agricultural enterprises to global requirements and competitive conditions. J. Galchynska (2023) analysed the peculiarities of developing a brand strategy for agricultural enterprises, highlighting the importance of brand positioning in the international market. A. Oriekhova *et al.* (2024) discussed global goals as a basis

for formulating a development strategy for agricultural enterprises, which pointed out the need to integrate global standards into the strategy of agricultural companies.

S. Abilda *et al.* (2024) considered in their research paper the adaptation of corporate strategies of agricultural enterprises in the context of crisis conditions, such as the COVID-19 pandemic, which emphasised the need for a flexible response to changes in market conditions. The paper also highlighted the importance of strategic adaptation to remain competitive in the global market. M. Mykhailchenko *et al.* (2021) assessed competitive human resource management (HRM) strategies in the business processes of agricultural enterprises focused on digitalization.

G. Doggalli (2024), in his study of risk management of agricultural enterprises, analysed risk management strategies, identifying them as an important component for successful entry into international markets. R. Komalasari & C. Mustafa (2023) studied the strategies for the development of agricultural products in Indonesia, where the authors emphasised the importance of innovative approaches to risk management in the new market conditions. The authors I. Zhofan *et al.* (2023) analysed the development of marketing strategies of agricultural enterprises in the grain markets of Ukraine and the People's Republic of China, which provided insight into specific approaches to international trade in the agricultural sector. W. Wenjie & A. Kurbanbaeva (2024) analysed human resource management strategies in agricultural formations, in particular, in the context of challenges and opportunities in global markets.

Thus, the studies together created a comprehensive picture of the current approaches and strategies of agricultural enterprises, which helped to understand how they adapted to global challenges and opportunities. Thus, the peculiarities of using strategies for entering foreign markets in the context of transformational changes require further research. This will allow a deeper understanding of how agricultural enterprises can effectively adapt their strategies to turbulent economic and political conditions.

The purpose of the study was to identify areas for improving the strategies of enterprises' entry into foreign markets based on an assessment of the development of the agricultural sector of Ukraine. To achieve this goal, the study set the following objectives: to identify the peculiarities of the development of the agricultural sector in European countries; to outline the motives and existing strategies for entering the foreign market of agricultural enterprises; to review the strategies for entering the foreign market of agricultural enterprises in Ukraine and to propose areas for their improvement.

► Materials and methods

The EU was chosen to analyse the development of the agricultural sector because of its influence on the global agricultural market and its important role in shaping agricultural standards and policies at the international level. The EU was also chosen because it has structured statistics and data that allow for a detailed and comprehensive analysis of the agricultural sector. Initially, data were collected on the structure of the agricultural sector, crops, livestock, and the dynamics of exports and imports of agricultural products for the period from 2002 to 2022. The period from 2002 to 2022 was chosen for analysis due to the implementation of the Common Agricultural Policy (CAP) reform in 2003, the active enlargement of the EU in 2004 and 2007, the impact of global economic crises, the growing role of environmental standards, and the availability of structured data for in-depth analysis of the agricultural sector (Eurostat, 2024a; 2024b; 2024c; Trading Economics, 2024; European Commission, 2023; 2024). The analysis was based on the Wilcoxon method, which was used to compare the medians of different groups of data and assess the statistical significance of changes in the dynamics of exports and imports. This non-parametric test made it possible to identify statistically significant differences in the indicators and assess the trends in the development of the agricultural sector in the EU. The percentage distribution of agricultural production by sector, the proportions of different crops and the share of different types of livestock, as well as changes in the volume of exports and imports of agricultural products were analysed, which allowed us to identify the main trends and changes in the foreign economic activity of the EU agricultural sector.

Data on the dynamics of Ukrainian goods exports for the period 2015-2023 was collected. The period of 2015-2023 was chosen for analysis because of its relevance to important events, such as the launch of the EU-Ukraine Association Agreement in 2014, the active integration of the Ukrainian economy into world markets, as well as significant changes in export dynamics caused by economic and political factors and the full-scale war with Russia that began in 2022. For this purpose, we used statistical reports and databases from official sources that provided information on agricultural exports (National Bank of Ukraine, 2024; TOP-10 wheat producing countries in 2022/23 MP, 2023; Food and Agriculture Organization, 2022). The collected data was systematised by year, which made it possible to assess changes in export volumes and identify trends based on the figures in millions of US dollars. All export data were segmented by product category and buyer country. The countries that purchased Ukrainian agricultural products from March 2022 to May 2023 were analysed separately, which allowed us to track the geographical structure of exports in detail. This made it possible to identify the main partners and assess changes in export markets influenced by geopolitical events.

For a detailed analysis, 15 leading Ukrainian agricultural companies were selected, including Kernel, Myronivsky Hliboproduct (MHP), Nibulon, Lebedynsky Seed Plant (LSZ), UkrLandFarming, Astarta-Kyiv, Agroprosperis, Epicentre Agro, Continental Farmers Group, AgroVista, Industrial Milk Company (IMK), KSG Agro, Ukrprominvest-Agro, HarvEast and Prometey (Ukrainian Business

Award, 2024). For each of these companies, data was collected on several key criteria as of 2023: the duration of their operations in the market, the area of their land bank in thousands of hectares, the number of countries to which their products were exported, and the total number of employees, expressed in thousands of people based on the data collected. The assessment was carried out using scores for each criterion, which allowed us to compile an overall rating of the companies. These indicators made it possible to form a rating of enterprises and conduct a comprehensive assessment of them, including an analysis of their efficiency and competitiveness in the agricultural sector of Ukraine.

► Results

Peculiarities of agricultural sector development in European countries. European agribusinesses operate in a challenging environment characterised by high levels of EU regulation, environmental requirements and ongoing climate change. They face challenges from fluctuating market prices for raw materials and products, dependence on weather conditions and the need to adopt innovative technologies to increase efficiency. In addition, the agricultural sector faces difficulties in preserving biodiversity, water resources and soil quality, which is exacerbated by the impact of climate change. The system of subsidies and support from the EU partially offsets these risks, but businesses remain vulnerable to global market fluctuations and political changes.

In 2023, the EU's agricultural sector contributed 1.3% to the region's gross domestic product (GDP) (1.4% in 2022), which is the same level as 15 years ago (Eurostat, 2024b). Although this contribution may seem small, agricultural production, which is generated mainly by small farms, is big business and has a significant impact on the EU economy. The total contribution of the agricultural sector to the EU economy in 2023 was approximately EUR 219.5 billion (Eurostat, 2024c), which is comparable to the GDP of Greece in the same year, the 16th largest economy among EU countries, which was EUR 257.548 billion in 2023 (Trading Economics, 2024). This contribution, reported as gross value added at producer prices, is the difference between the value of agricultural output and the costs of the various inputs used in the production process, including taxes and product subsidies.

The gross value added of the EU agricultural industry in 2023 was EUR 225.6 billion, meaning that for every euro spent on goods and services in production, the EU agricultural sector generated EUR 0.72 in value added. This figure was lower than the peak of 0.79 in 2017 and in all subsequent years except 2022. This suggests that while the agricultural sector continues to be an important source of economic value, its efficiency in generating value added per unit of input has declined compared to previous years (Eurostat, 2024a). This decline may indicate higher production costs, reduced profitability, or other economic challenges faced by the agricultural sector in the current environment. The total value of output generated by the EU's agricultural sector in 2023 was EUR 537.1 billion. The majority of this value (51.3%) was accounted for by plant products, which were valued at EUR 275.8 billion (Fig. 1).

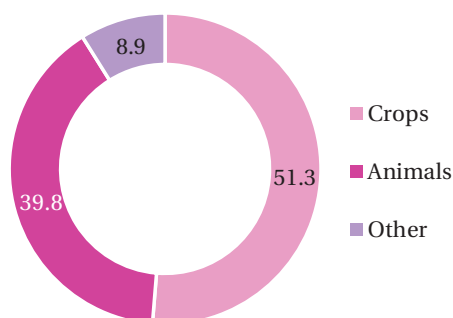


Figure 1. Structure of the agricultural sector in the EU countries, as of 2023, in %

Source: compiled by the authors based on Eurostat (2024a)

The most valuable crops were vegetables, horticultural plants and cereals. Livestock and animal products accounted for almost two-fifths (39.8%) of the total value of output, with milk and pork being the largest contributors. Agricultural services (EUR 24.8 billion) and other non-farm non-professional activities (EUR 22.8 billion) accounted for the remaining 8.9%.

The analysis of the crop structure of the EU agriculture sector for 2024, presented in Figure 2, shows the

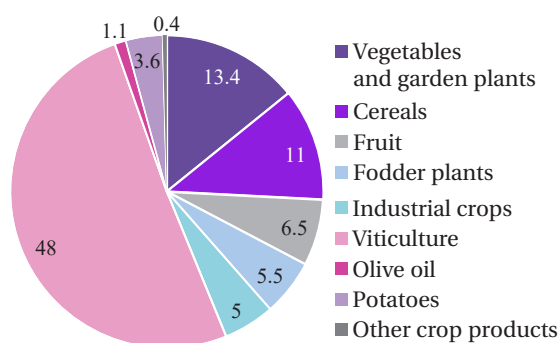


Figure 2. The structure of crops in the EU agricultural sector as of 2023, in %

Source: compiled by the authors based on Eurostat (2024a)

dominance of the viticulture industry, which accounts for 48% of total production, reflecting the traditional agricultural characteristics of the region, especially in countries such as France, Italy and Spain, where the culture of vineyard cultivation has deep roots. Vegetables and horticultural plants (13.4%) and cereals (11%) also show a significant representation, highlighting the importance of these crops for food security and dietary diversity.

The structure of EU livestock production, as shown in Figure 3, shows that milk (13.9%) and pigs (9.2%) dominated in 2023, reflecting deep market traditions and consumer preferences. Dairy farming is important due to the stable demand for dairy products, which are a major part of the EU diet.

Pig production is also an important sector due to the high popularity of pork and the efficiency of its production. Cattle (6.6%) and poultry (5%) showed a smaller share, reflecting higher costs and specific consumer preferences. The small contribution of eggs (3%) and other animals (1.6%) may be due to limited demand or lower economic benefits compared to the main products. This structure is due to both historical traditions and current economic factors that shape demand for different types of livestock products in the EU. The dynamics of exports and imports of EU agricultural products in 2002-2022 are shown in Figure 4.

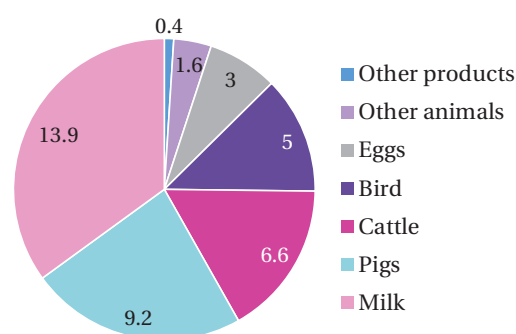


Figure 3. Structure of livestock production in the EU countries as of 2023, in %

Source: compiled by the authors based on Eurostat (2024a)

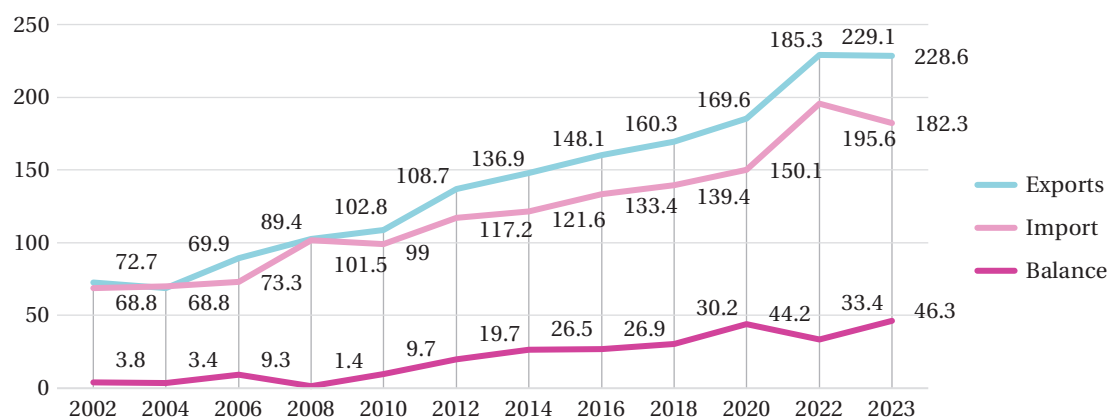


Figure 4. Dynamics of exports and imports of agricultural products in the EU in 2002-2023, EUR billion

Source: compiled by the authors based on Eurostat (2024a)

The analysis of the data in Figure 4 shows that over the period 2002-2023, there was a steady increase in both exports and imports, indicating that the EU's trade activity on world markets has increased. Particularly notable is the growth of exports, which outpaced the growth of imports, resulting in a gradually increasing foreign trade surplus. Since 2012, the upward trend in the balance has become more pronounced, indicating an increase in the competitiveness of EU products and the strengthening of its position as an export-oriented region.

Thus, the EU agricultural sector has a number of key features that influence the decision of agricultural companies when choosing a strategy for entering the foreign market. The large share of people employed in the sector (17 million people, most of whom work on temporary contracts) indicates the seasonal nature of work and employment instability. The imbalance in the distribution of land, with 52% of agricultural land controlled by only 4% of large farms, highlights the processes of industrialization in agriculture. At the same time, the dominance of small farms (40% of farms occupy less than 5 hectares) indicates significant challenges that they must overcome to be competitive. A significant share of budget subsidies through the CAP, which allocates EUR 264 billion to support farmers, helps to ensure stable incomes, although farmers' income levels remain 40% below the EU average wage (European Commission, 2024).

The sector also faces challenges in meeting environmental standards, as production contributes to greenhouse gas emissions, especially methane, which slows down the achievement of climate goals. Despite these challenges, the EU's agricultural sector has achieved significant self-sufficiency in food supply, allowing it to remain a powerful player on the global market.

Motives and existing strategies for entering the foreign market of agricultural enterprises. Entering foreign markets for agricultural enterprises is a complex process that involves developing strategies to expand the enterprise's activities beyond the domestic market. One of the

main reasons for this step is the desire for operational diversification. Companies that depend on only one market may face sharp fluctuations in demand or economic instability. Entering international markets helps to mitigate these risks by providing a more stable revenue stream. Another crucial motive is the need to find new markets. The domestic market may be oversaturated, or consumer demand may be limited due to economic conditions. In this case, international markets open up new opportunities for sales, especially for businesses offering unique or high-quality products.

In addition, entering foreign markets helps to increase brand awareness. Businesses operating in the international arena can significantly expand their audience, which in turn can lead to increased sales (Mayis *et al.*, 2021; Babenko *et al.*, 2023). Gaining trust in new markets can be a fundamental factor for the long-term success of an enterprise.

Increased revenues are also a significant incentive. By expanding their customer base beyond national borders, agricultural enterprises have the opportunity to sell their products in regions with higher purchasing power or where there is a high demand for certain products. Thus, access to international markets is an essential strategy for the long-term development, growth, and sustainability of agricultural enterprises.

Therefore, modern agricultural enterprises are actively looking for ways to enter foreign markets, given the growing competition and constant changes in international trade. Important elements in choosing a strategy include analysing market opportunities, adapting to the legal requirements of different countries, and introducing innovative technologies in production and sales. In addition, agricultural enterprises should take into account the specifics of demand in the German, French, and English markets, which affects the positioning of products and the determination of sales channels. Table 1 below summarises the existing foreign market entry strategies used by agricultural companies.

Table 1. Analysis of existing strategies for entering the foreign market of agricultural enterprises

Strategy	Description	Features	Risks
Product differentiation strategy	Aimed at creating a unique value or quality of agricultural products that differs from competitors and meets the specific needs of consumers.	The ability to create high demand for products. Entering premium market segments. Less competition due to the uniqueness of the product.	High costs of developing and promoting unique products. The risk of competitors copying the product. The difficulty of sustaining innovation in the long term.
Pricing strategy (cost leadership strategy)	Focusing on reducing production costs to set a competitive price for products, which allows the company to compete on the basis of the cost of goods.	Quick market penetration due to affordable prices. Opportunity to increase sales volumes due to low prices. Increase market share in the mass segment.	Decreased profitability due to low margins. The quality level may be lowered due to cost savings in production. Competition with other businesses that also reduce prices.
Innovation strategy	The introduction of new technologies, processes, or products that allow the company to enter foreign markets more effectively and increase competitiveness.	The ability to create a competitive advantage in the market. Improving the efficiency of production processes. Attracting new customers through innovative solutions.	High innovation costs. The risk of failure of new technologies. The rapid obsolescence of technology and the need to constantly invest in new developments.

Table 1, Continued

Strategy	Description	Features	Risks
Expansion into new markets	Focusing on expanding the company's presence in new geographical regions or countries by actively seeking new markets and partners.	Diversification of market risks. Attracting new customers and increasing sales. The ability to enter markets with less competition.	High costs of researching new markets and marketing. Difficulties in adapting products to local conditions. There may be problems with regulatory requirements in new countries.
Branding strategy	Building a strong brand that helps to distinguish the agricultural enterprise's products in the market and creates trust among foreign consumers.	Building a loyal customer base. Increase in product value due to brand awareness. Strengthening market position through association with quality and reliability.	High costs for brand development and promotion. A long process of building awareness in new markets. The risk of unsuccessful brand perception in another culture or country.
Sustainable development strategy	Focusing on environmental friendliness and social responsibility in production processes, which meets the modern requirements of international markets for sustainable development.	Attracting environmentally conscious customers. Possibility of obtaining additional certificates and grants. Positive image among consumers and partners.	High costs of implementing environmental standards. There may be difficulties with certification in different countries. The risk of high product costs for some market segments.
Localization strategy	Adaptation of products, marketing, and business processes to the specifics of each foreign market to compete more effectively and meet the needs of local consumers.	The ability to meet market needs precisely. Increase the chances of successful entry into regional markets. Increase loyalty among local consumers.	High costs for product adaptation. Risk of ineffective management due to a variety of strategies for different markets. The need for research and understanding of local conditions.

Source: compiled by the authors based on D. Chatterjee (2024) and S. Yang (2024)

An analysis of existing strategies for entering foreign markets revealed that each has its limitations. Strategies that focus on cost reduction or innovation may not be practical due to high upfront costs and the rapid obsolescence of technology. Other approaches, such as expanding into new markets or branding, often face adaptation problems and cultural barriers, which often reduce their effectiveness (Tanasiichuk *et al.*, 2024). In particular, localization and sustainability require significant resources to adapt to specific market conditions and comply with environmental standards, which is not always justified in the context of limited budgets. Thus, the effectiveness

of strategies largely depends on the specific context and resources of the enterprise, which requires a cautious approach and flexibility in their implementation.

Overview of strategies for entering the foreign market of Ukrainian agricultural enterprises and directions for their improvement. According to National Bank of Ukraine (2024), Ukraine's agricultural exports gradually increased during 2015-2023, reaching a record 63.44% of total exports in 2023, which demonstrates the importance of the agricultural sector for the Ukrainian economy, especially in the context of the decline in other export sectors due to the war (Fig. 5).

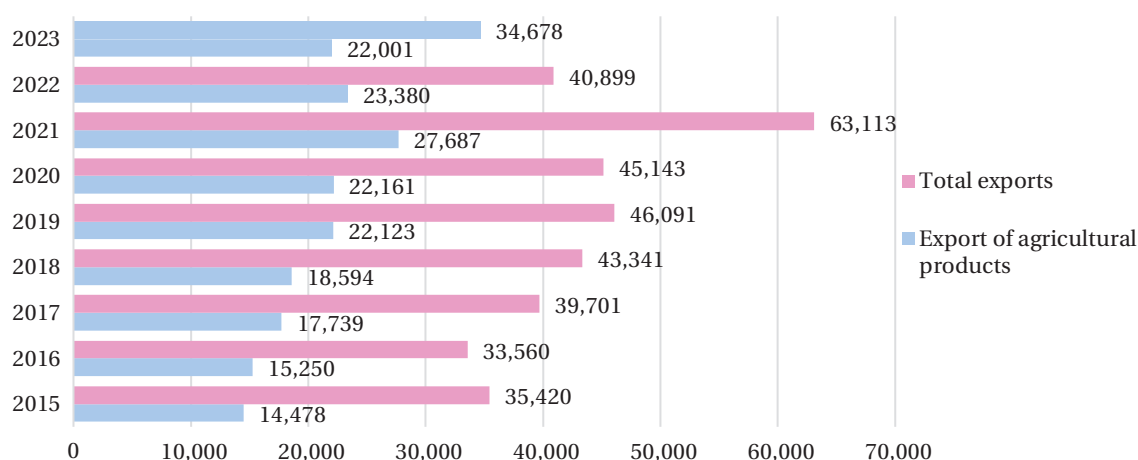


Figure 5. Dynamics of Ukrainian exports of goods in 2015-2023, USD million

Source: compiled by the authors based on National Bank of Ukraine (2024)

Analysing these data, it should be noted that the agricultural sector remains key to Ukraine's exports, even in the context of a decline in overall trade. The growing share of agri-food products in the export structure underlines its strategic importance for the country's economy, although the overall economic situation, including the impact of the war and disruption of logistics chains, has led to a decline in exports in monetary terms.

It is also interesting to see to which countries Ukrainian agricultural companies are successfully selling their products and strengthening their strategies, as most agricultural companies start their expansion into foreign markets as exporters and only then use other means of penetration. Figure 6 shows a diagram that demonstrates the shares of countries that buy agricultural products from Ukraine.

The above 10 countries accounted for about 63% of foreign exchange earnings for the agricultural sector. The main export products were grains and oilseeds (Fig. 7).

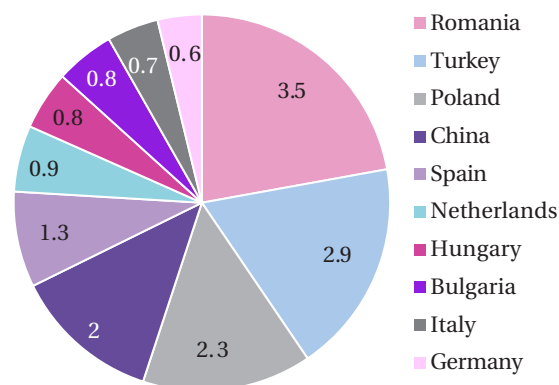


Figure 6. Countries that purchased Ukrainian agricultural products in the period from March 2022 to May 2023

Source: compiled by the authors based on National Bank of Ukraine (2024)

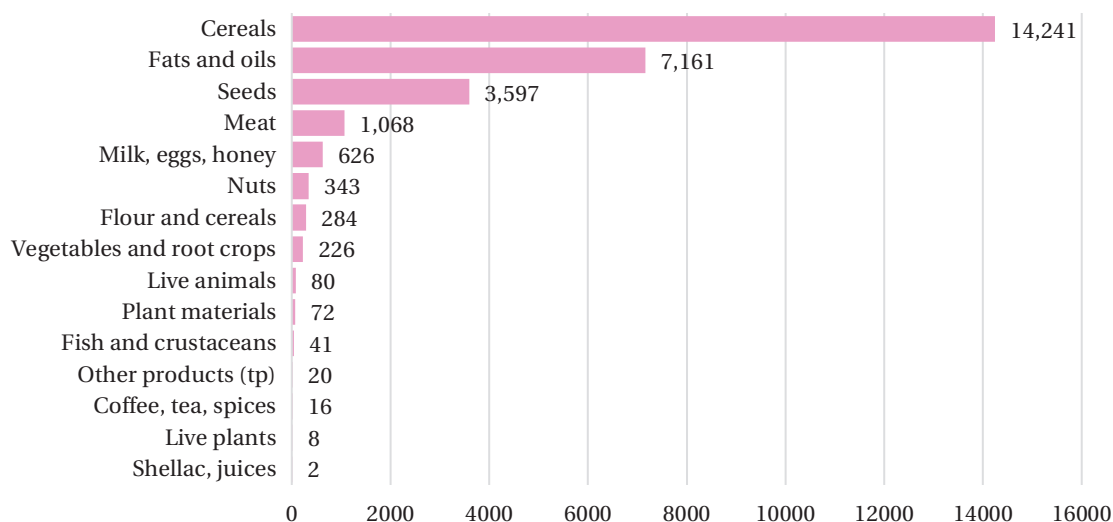


Figure 7. Commodity structure of Ukraine's agricultural exports in 2022-2023, USD mln

Source: compiled by the authors based on National Bank of Ukraine (2024)

The above data on the commodity structure of Ukraine's agricultural exports in 2022-2023 showed that the country has a clear dominance in the export of cereals and fats and oils, which account for a significant portion of foreign exchange earnings. Grain crops are the main export commodity, followed by fats and oils, which underlines the importance of agriculture in Ukraine's economy. However,

such a narrow specialization in certain products may indicate a dependence on these commodity groups and a need to diversify export supplies to reduce the risks associated with fluctuations in world prices. Table 2 shows the analysis of the best agricultural enterprises in Ukraine according to the Ukrainian Business Award information and analytical agency as of 2024 (Ukrainian Business Award, 2024).

Table 2. Rating of the best agricultural enterprises in Ukraine as of 2024

Rank	Agricultural enterprise	Years on the market	Land bank, thousand ha	Exports (number of countries)	Number of employees, thousand people	Points	Points (%)
1	Kernel	29	514	60	11	15.16979656	100
2	MHP	26	362	85	28	14.03306285	92.5
3	NIBULON	32	76	75	4	10.89763141	71.8
4	LNZ	10	90	25	3.5	9.026536805	59.5
5	UkrLandFarming	17	475	40	25	8.259867275	54.4
6	Astarta-Kyiv	31	220	40	7	7.168133474	47.3
7	Agroprosperis	17	300	37	4	5.023283932	33.1
8	Epicentre Agro	9	167	10	4.2	4.939948515	32.6

Table 2, Continued

Rank	Agricultural enterprise	Years on the market	Land bank, thousand ha	Exports (number of countries)	Number of employees, thousand people	Points	Points (%)
9	Continental Farmers Group	32	195	30	2.4	4.929981454	32.5
10	AgroVista	24	82	20	1	4.37004783	28.8
11	IMK	17	123.9	30	2.3	4.258393035	28.1
12	KSG Agro	23	24	20	1	3.739358473	24.7
13	Ukrprominvest-Agro	24	108	10	4.6	3.648572846	24.1
14	HarvEast	13	127	5	1.8	2.40317734	15.8
15	Prometey	23	20	2	1.3	2.132208192	14.1

Source: compiled by the authors

In 2024, the ranking of the best agricultural enterprises in Ukraine demonstrated significant differences in the scale of operations and achievements of companies. Kernel Agricultural Holding was the undisputed leader of the ranking, receiving the highest score due to its huge land bank of 514,000 hectares and active export market covering 60 countries. In this context, it should be added that Kernel uses a geographical diversification strategy by opening new markets, which allows it to reduce the risks associated with price fluctuations in its main markets. In addition, Kernel is actively investing in improving its supply chain, including upgrading port facilities and transport, to ensure efficient delivery of products to different countries.

MHP has also achieved strong results thanks to its large land bank (362,000 hectares) and a broad sales market in 85 countries. MHP applies a vertical integration strategy that includes its own production facilities and controls all stages of the supply chain, from growing raw materials to processing and exporting. This approach allows us to reduce costs and ensure high quality products. In addition, MHP is actively developing its corporate social responsibility strategy, which includes support for local communities and environmental initiatives, improving the company's image in international markets.

In contrast to the leaders, Prometey Agro Holding was ranked last in the ranking due to its limited land bank (20,000 hectares) and insignificant exports to 2 countries. The company faces difficulties in scaling up its business and underdeveloped strategic partnerships. To improve its position, Prometey needs to implement an expansion strategy to new international markets and increase its land bank.

Other companies, such as Astarta-Kyiv and Agroprosperis, have also demonstrated different approaches to international markets. Astarta-Kyiv focuses on product diversification and expanding sales channels through strategic alliances, while Agroprosperis is actively investing in innovative technologies to improve productivity and product quality. The rating highlighted the importance of a combination of a large land bank, effective employee management, developed export activities and strategic investments to achieve strong results in the Ukrainian agricultural market.

Agribusinesses such as Kernel and MHP are actively using branding and localization strategies, and thus have a better chance of gaining a long-term foothold in foreign markets, as this allows them to better adapt to the specifics of local consumer preferences and cultural characteristics.

It should also be added that all the above agricultural enterprises are actively implementing environmental standards and principles of sustainable development, which increases their attractiveness not only for European markets, especially given the growing demand for organic and environmentally friendly products. The foreign economic strategy used by Ukrainian agricultural enterprises often requires improvement due to the high level of competition in the agricultural market (Penkova & Kharenko, 2023).

The main areas for improving Ukraine's agricultural exports include expanding the geography of supplies, especially to Asia and Africa. These regions are experiencing significant population growth, leading to increased demand for processed grain products. The Asian and African markets, in particular China and India, are strategically important due to their huge potential for agricultural consumption. Active entry into these markets could provide Ukrainian producers with new sales channels and reduce their dependence on traditional consumers, which could be beneficial in the event of changes in the global economic situation.

It is also worth noting that due to military conflicts and other geopolitical restrictions, traditional transport routes for exports are hampered. Therefore, it is crucial to refocus on new logistics routes, in particular, using rail and road transport. Alternative routes, such as rail corridors through Poland or roads through Romania, can ensure the stability of supplies. Using ports in neighbouring countries, such as those in Gdańsk or Constanta, would help avoid delays and reduce dependence on blocked ports in Ukraine.

Improving the quality of exported products is another critical aspect. In particular, the quality of grain can decline during transportation due to mechanical damage and impurities. To reduce the risk of quality deterioration, modern packaging and storage technologies should be introduced. For example, investing in improved ventilation and moisture protection systems can help preserve grain quality until it is delivered to the end user.

Reducing production and transportation costs is also essential for increasing the competitiveness of Ukrainian agricultural products. Grain drying costs can account for more than 35% of the total cost of production, so the introduction of energy-saving technologies is an important step (Shyian *et al.*, 2020). The introduction of new energy-efficient technologies will not only reduce costs but also contribute to environmental goals. In addition, improving the image of companies through participation

in international exhibitions, investments in social responsibility and environmental initiatives will help strengthen their competitive position in the global market and ensure sustainable growth in profitability and development.

► Discussion

The results of the study confirmed that the problem of achieving competitive advantages of modern enterprises through an effective strategy of their entry into the foreign market is extremely relevant in the context of rapid changes in the globalised business space. In this context, the agricultural sector is distinguished from others by its significant dependence on technological progress, resource base and state support. It is noted that this sector requires continuous improvement in production processes and adaptation to changing market conditions. The author substantiates the need to introduce innovations and sustainable development to ensure the long-term competitiveness of Ukrainian agricultural enterprises in the world market.

These findings are in line with those of other authors, such as E. Raji *et al.* (2024), who studied the integration of technology and market strategies in the agricultural economy. The authors emphasised that technological advances such as precision agriculture, the Internet of Things, artificial intelligence, drones, and biotechnology are transforming agricultural practices, allowing for informed data-driven decision-making, resource optimization, and efficiency gains. The authors' conclusions that agribusinesses gain competitive advantages by enhancing product differentiation and optimizing supply chains through innovative digital tools appear well-founded. Policymakers play an important role in facilitating this integration by supporting innovation, developing digital infrastructure and sustainable agricultural practices (Shahini *et al.*, 2023; Abad *et al.*, 2024).

And other authors R. Guo *et al.* (2021) and H.F. Atli (2024a, 2024b) determined that strategies, namely strategic positioning and innovative marketing, use these technologies to meet changing consumer needs and expand market opportunities. Indeed, according to the authors, the principles of strategic management ensure that these technologies and strategies are aligned with long-term goals, promoting innovation and sustainability in agricultural enterprises. The current study also emphasises that the effective integration of technological innovations with market strategies is an imperative for achieving competitive advantage in international markets. It is pointed out that agricultural enterprises must actively innovate and adapt their strategies to market conditions in order to remain competitive and meet global requirements. In the conclusions of the authors V. Aliabadi *et al.* (2024), and L. Ma & T. Wang (2024), who studied the innovative aspect of agricultural enterprises, also suggest that the use of modern technologies, such as digital marketing and strategic positioning, helps not only to meet the current needs of consumers, but also to increase the overall efficiency and sustainability of the agricultural sector in the context of globalization.

The current study also noted that a properly selected approach to the selection and management of the strategy of an agricultural enterprise when entering the international market is a key to ensuring its competitiveness in it.

Adapting the strategy to market specifics, taking into account the changing conditions of globalization and integrating the latest technological solutions to improve production efficiency and reduce risks are essential aspects (Parkhomets *et al.*, 2023). These conclusions are in line with the research work of F. Hemmati *et al.* (2018), which emphasises that competent management, management experience, dedication, expertise, and goal orientation are factors that influence the export development of SMEs. W. Duan *et al.* (2024) also noted in their study that the implementation of certification standards and effective market access management have a significant impact on improving economic sustainability in rural China, which is consistent with the findings of the current study on the importance of adapting strategies and technological innovation to succeed in the international market.

The results of the current study have confirmed that differentiation and cooperation are successful strategies for agricultural enterprises to enter the global market. Differentiation, which includes the development of unique products and the introduction of innovative technologies, allows agricultural companies to stand out from competitors and meet the specific needs of global consumers (Stepanenko *et al.*, 2023; Tkachuk *et al.*, 2024). Cooperation, in turn, helps to reduce costs by sharing resources, and provides access to new markets and technologies through partnerships with other businesses or organizations. These findings are consistent with the study by Z. Hu *et al.* (2022), and X. Chen *et al.* (2020), which found that cooperatives can be economically successful if they participate in alternative agri-food systems that focus on product quality and authenticity. In the Chinese context, where many farmer cooperatives have had difficulty integrating into conventional agri-food systems, only those that focus on environmentally sustainable farming and alternative distribution networks have achieved economic sustainability. Other authors V.K. Dagbelou *et al.* (2021), and S.R. Swaffield *et al.* (2019) also focused on the fact that in order to succeed in the global market, agricultural enterprises need not only to use differentiation strategies, but also to actively engage in cooperative initiatives that promote sustainable development and improve economic efficiency.

The current study also focuses on riskiness, as the effectiveness of agricultural enterprises' strategies for entering the global market is directly related to possible financial and operational risks. The most common risks usually include fluctuations in raw material prices, unforeseen changes in international regulatory requirements, and logistical problems that can significantly affect the success of expansion (Denysiuk *et al.*, 2023). The study by J. Wang (2024) also analyses the risk aspect of agricultural enterprises. In his research paper, the author emphasised that economic globalization promotes the development of international trade and increases the importance of international settlements as an integral part of this process. J. Wang noted that in the context of agricultural products, which are subject to risks, such as market price volatility and periodic product deterioration, risk management is of particular importance. The author noted in his study that agricultural enterprises, such as AGRIGULE, need to integrate adapted payment methods and management strategies to reduce risks and improve their competitiveness.

in international markets. This is in line with the findings of the current study on the need to develop internal risk management systems and adapt strategies to global market conditions.

The study also found that investments contribute to the active implementation of agricultural enterprises' strategies for entering the international market. The results of the study confirmed that effective investment management is an important factor for the implementation of successful expansion strategies of agricultural enterprises in the international arena. It should be noted that such conclusions coincide with those of R. Kastratović (2023), who emphasised that foreign direct investment plays a pivotal role in the export decisions of agricultural companies. L. Cochrane *et al.* (2023) also noted that the failure of foreign investment in the agricultural sector may be due to insufficient assessment of market risks and lack of adaptation to local conditions. Their study of Ethiopia demonstrated that careful analysis and a strategic approach to investment can help avoid common mistakes and ensure successful entry into international markets.

Thus, this study has confirmed that the successful entry of modern enterprises, especially agricultural ones, into the international market depends on the integration of innovations, adaptation of strategies to the changing conditions of globalization and effective risk management. It has been found that in order to achieve competitive advantages, it is relevant to use strategies such as product differentiation, strategic positioning and development of new markets, which contribute to increasing efficiency and reducing risks.

►Conclusions

The purpose of the study was achieved by analysing the current state of enterprises' activities on the example of the agricultural sector of Ukraine, which allowed identifying key areas for improving strategies to increase their competitiveness in foreign markets.

In 2023, the EU's agricultural sector showed stable development, contributing around 1.3% of EU GDP with a total contribution of EUR 219.5 billion, which was in

line with the GDP of countries such as Greece. The sector generated gross value added of EUR 0.72 for every EUR of production costs, which was slightly lower than in previous years. The total value of output reached EUR 537.1 billion. The livestock industry also remained important, with milk and pork accounting for 13.9% and 9.2% of output, respectively. At the same time, the sector faced challenges from environmental standards, such as reducing greenhouse gas emissions and preserving natural resources, but remained self-sufficient in food supply and maintained a strong position on the global market.

The study found that the motives for agricultural enterprises to enter foreign markets are to increase revenues, gain access to new markets and diversify risks. The main strategies for this are participation in international trade agreements, implementation of quality standards that meet international requirements, and establishing partnerships with foreign buyers.

The study found that in 2013-2023, the agricultural sector remained a key sector of the Ukrainian economy, accounting for more than 40% of export revenues. However, the full-scale war that began in 2022 has worsened the situation of agricultural enterprises. Therefore, it is crucial to adapt the agricultural sector in the regions where there are no active hostilities to the new conditions. With its significant agricultural potential, Ukraine continues to actively integrate into the global agricultural market. The main export sectors include grains, oilseeds, and food products. However, Ukrainian enterprises face numerous challenges, such as imperfect logistics infrastructure and political and economic instability, which affect export opportunities. To improve the situation, it is necessary to invest in infrastructure modernization, introduce new technologies for export management, and expand cooperation with international trade organizations and investors.

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►Conflict of interest

The authors of this study declare no conflict of interest.

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► **Анотація.** Дослідження було спрямоване на висвітлення особливостей формування й використання стратегій виходу на зовнішній ринок сучасних господарюючих суб'єктів на прикладі підприємств аграрного сектору економіки. Для обробки даних використовувалися методи економіко-статистичного аналізу, включаючи статистичний метод Вілкоксона для порівняння тенденцій, а також бальний метод. В поточному дослідженні визначено особливості розвитку аграрного сектору в країнах Євросоюзу та України зокрема, звернено увагу на основні виклики та можливості, з якими стикаються аграрні підприємства в умовах глобалізації. З'ясовано, що розвиток аграрного сектору залежить від доступу до ресурсів, технологічного прогресу та відповідної державної підтримки. Наголошено на важливості впровадження інновацій та залучення інвестицій для підвищення конкурентоспроможності підприємств аграрного сектору економіки. Окреслено основні мотиви та стратегії їх виходу на зовнішні ринки, серед яких: стратегія диференціації продукту, цінова стратегія (стратегія лідерства за витратами), стратегія інновацій, експансія на нові ринки, стратегія брендингу, стратегія сталого розвитку, стратегія локалізації. Проаналізовано аграрний сектор України та зроблено огляд стратегій виходу на зовнішні ринки 15 українських аграрних підприємств, звернено увагу на наявні проблеми в інфраструктурі та логістиці. Обґрунтовано напрями вдосконалення, які включають інвестиції в модернізацію, розвиток логістичних мереж та підвищення якості продукції відповідно до міжнародних стандартів, що сприятиме підвищенню їх конкурентоспроможності на глобальному ринку. Отримані результати підкреслили важливість комплексного підходу, що включає стратегії диференціації продукту, цінової конкуренції та інновацій для забезпечення конкурентоспроможності аграрних підприємств на глобальному ринку, а також необхідність адаптації стратегій до специфіки місцевих ринків і тенденцій сталого розвитку

► **Ключові слова:** аграрний сектор економіки; інноваційно-інвестиційний сталий розвиток; експансія; експорт продукції; диверсифікація ризиків; ефективне управління; державна підтримка



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Methodical aspects of determining strategic directions for the development of rural areas of amalgamated territorial communities

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► **Abstract.** The relevance of the study is to develop an economic and mathematical model for tactical and strategic planning of socio-economic development of rural areas of amalgamated territorial communities. The purpose of the study was to improve and apply methodological tools for determining strategic directions of development of rural territories of amalgamated territorial communities on the example of Vinnytsia region. The following methods were used: comparative analysis, statistical, tabular, graphical, calculation and design, abstract and logical. The proposed methodological tools and the algorithmic sequence of its practical implementation made it possible to identify structural and aggregate economic, social and environmental indicators of rural development of the amalgamated territorial communities, to model the relevant list of priority problems and to substantiate the directions of their minimisation. By modelling the strategic directions of rural development on the basis of a set of economic, social and environmental factors using the methodological tools of fuzzy set theory, it is established that the overall indicator of rural development in terms of the economic block is within the optimal rate of development (0.849), in terms of the dynamics of the share of investment in the agricultural sector of the economy – exceeds the satisfactory level (0.771), in terms of financial performance indicators it is reaching a threatening level (0.387). It has been established that the integral indicator of rural development in the social block is within the satisfactory rate (0.702), and according to indicators of the quality of life of the population, it is at a threatening pace (0.490). Accordingly, a monitoring rating of priority social problems of rural development that need to be addressed has been formed. It was determined that according to the dynamics of ecological calculation indicators; the general indicator for the environmental block is within the limits of a satisfactory rate of rural development (0.650). The modelled ranking of the priority problems of rural development are presented in the following sequence of their minimisation: economic – E_4, E_3, E_2, E_1 ; social – $S_6, S_4, S_1, S_2, S_3, S_5$; environmental – Ek_1, Ek_2 . The practical results of the study make it possible to objectively assess the advantages, challenges and risks of rural development of the rural areas of the amalgamated territorial communities of Vinnytsia region, contribute to the prioritisation of solving economic, social and environmental problems and can be useful in regional management practice for the developing strategic directions for further intensification of community development

► **Keywords:** economic indicators; social indicators; environmental indicators; integral indicator; variational model; intensification of rural development

► Introduction

The amalgamation of neighbouring territorial communities in the course of the 2015-2020 decentralisation and territorial-administrative reform is aimed at transferring

the functions to local self-government, which allows for the intensification of rural development. The concept of development of amalgamated territorial communities

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(ATC) is focused on agricultural production, self-organisation, local resources, infrastructure and investment attractiveness. It is important to develop an adaptive mathematical model for assessing and modelling strategic directions of rural development that takes into account economic, social and environmental indicators. This will help identify effective development vectors and ensure effective planning (Pietrzyk, 2022).

The issues of rural development efficiency, development of methodological tools for its measurement and modelling of forecast parameters of activation are the subject of research by many authors. In her research, O. Lazarijeva (2019) proposes to use a set of indicators that characterise the efficiency of land use, namely: the level of provision of agricultural land, the dynamics of crop and livestock production per unit area, a set of profitability indicators and profitability of production of various types of agricultural products, etc. to assess the sustainable development of rural areas. The author notes that the use of these indicators will allow not only to identify the reasons for the inefficient use of the land resource potential of rural areas, but also to outline the priority areas for its stabilisation and further economic growth.

N. Khomyuk & N. Pavlikha (2019) propose a methodological toolkit that comprehensively combines the monitoring the level of rural development and developing strategic directions for its further activation. The main methodological approach proposed for analysing rural development is the toolkit for calculating an integral index, which systematically involves the selection and justification of the necessary array of quantitative and qualitative indicators. The authors propose to substantiate the strategic parameters of rural development by building a model of diversification of rural development with further indicative monitoring of its results.

A. Sava *et al.* (2020) propose to determine the strategic directions of rural development through the development and practical processing of econometric models. In their study, the authors focused on measuring the correlation-regression relationship between the state of rural areas and structurally differentiated factor influence. It was established that factor combinations with a negative value of the regression coefficient have a stronger influence on the state of rural areas than factors with high positive values of the R^2 indicator. In their opinion, the economic and mathematical modelling tools substantiated by the authors allow to identify a set of problems of rural development that need to be minimised and solved as a matter of priority.

K. Patytska *et al.* (2021) substantiated the methodology for determining the budgetary capacity of territorial communities. The authors identified the income component of the community budget as the basic indicator of the proposed methodology, which objectively reflects the current state and existing problems of its economy. The authors link the prospects for the development of amalgamated territorial communities with their budgetary capacity. In their opinion, structural monitoring of local budget revenues, analytical determination of the sources and features of their formation, measurement of the structure of the community's own income and the dynamics of their negative shifts will contribute not only to ascertaining the existing problems of filling local budgets, but also help to determine

the real mechanisms of activation of rural development on the basis of gradual strengthening of budgetary capacity.

N. Kondratenko *et al.* (2022) in their study define the leading role of digitalisation and its tools in the development of rural areas. The authors claim that the gradual introduction of digital technologies and the creation of an effective information and communication environment will contribute to the development of villages and increase the quality of life of their residents.

I. Semihulina *et al.* (2022) devoted their study to substantiating theoretical and methodological recommendations for the development of methodological support for the practical implementation of the programmer and -project approach to managing the spatial development of ATCs. The authors interpret the methodological support toolkit as an integral system that combines methodological techniques of organisational and project management.

A. Kolosov *et al.* (2022) devoted their study to identifying current realities of the socio-economic life of rural and urban communities in Ukraine. The factor structuring of existing social and economic problems, intensified by modern global challenges, allowed the authors to determine real opportunities and scenario approaches for stable existence and further development. The authors identified and revealed the content of the priority factors of the modern development of the country's rural and urban communities and systematised the positive and negative features of their manifestation.

T. Panchyshyn & M. Vdovyn (2023) propose to assess the level of sustainable development of territorial communities and regions by identifying a systematic set of components and indicators using a multidimensional ranking tool, taking into account stimulant and destimulant indicators. The practical implementation of this methodological approach allows to determine both the rating of the leading regions and the list of regions with the worst indicative values.

Studies focus on substantiating the methodological aspects of assessing rural development without developing appropriate methodological tools for determining the strategic directions of their further intensification. Thus, it is worth stating the need for further research, substantiation, generalisation and in-depth methodological and practical processing of existing scientific works. The purpose of the study was to create methodological tools for determining strategic directions of rural development and its comprehensive testing on example of ATCs of Vinnytsia region. In order to achieve this goal, the following tasks needed to be implemented: to substantiate the methodological tools for calculating indicators of rural development of ATC by factor groups; to determine the dynamics of economic, social and environmental calculated indicators of rural development; to carry out an indicative structuring of the priority problems of rural development in the Vinnytsia region's ATCs with further justification of the sequence of their minimisation.

► Materials and methods

In the course of the study, a number of methods of scientific cognition were used. The method of comparative analysis was used for the structured formation of an array of calculation indicators of rural development for each

block of factors by dividing them by the maximum value. The tabular and graphical methods are used to visualise the results of the study. The statistical method was used to determine the arithmetic mean values for each calculated indicator according to the chosen structuring of factor groups of rural development of the ATCs of Vinnytsia region. The calculation and constructive method was used to determine the factor indicators and further structure the economic, social and environmental problems of rural development of the Vinnytsia region's ATCs. The abstract and logical method was used to substantiate the structural and logical sequence of the policy of minimising the totality of problems of rural development of the Vinnytsia region's ATCs and to formulate conclusions.

A conceptual feature of this study is an attempt to build a structured toolkit for strategic regulation of the development of rural areas of ATCs on the basis of fuzzy sets. A step-by-step algorithm for the formation of a variable model for enhancing the development of rural areas of ATCs is presented as follows.

The overall level of effectiveness of rural development of ATCs was identified in the form of a specific variable IR . The value of this variable indirectly depends on a structured set of economic, social and environmental factors. This dependence is illustrated in the form of the following formula:

$$IR = \phi(IR_e, IR_s, IR_{ek}), \quad (1)$$

where IR_e – a set of economic indicators (factors) of rural development, IR_s – a set of social indicators (factors) of rural development, IR_{ek} – a set of environmental indicators (factors) of rural development.

The block of economic indicators of rural development is tentatively structured into four factor groups:

- ▶ level of land availability E_1 ;
- ▶ level of entrepreneurial activity in rural areas E_2 ;
- ▶ the level of efficiency of the organisational and economic mechanism of management E_3 ;
- ▶ level of investment attractiveness and activity E_4 .

Mathematically, the variable economic component is presented as follows:

$$IR_e = \phi(E_1, E_2, E_3, E_4). \quad (2)$$

In turn, the factor groups that structurally form the economic block of impact indicators can be described using the following mathematical tools.

$$E_1 = \phi(e_1, e_2, e_3, e_4), \quad (3)$$

where e_1 is the total land area per 1 person, ha; e_2 – area of agricultural land per 1 person, ha; e_3 – the level of agricultural land development, %; e_4 – is the ploughed rate of agricultural land, %; e_5 – indicator of agricultural land availability, ha per one rural resident.

$$E_2 = \phi(e_6, e_7, e_8, e_9, e_{14}), \quad (4)$$

where e_6 is the number of agricultural enterprises per 10,000 population, unit; e_7 – is the share of small enterprises, %; e_8 – is the number of enterprises in the agricultural sector, unit; e_9 – is the share of the total amount, %; e_{14} – is the share of agricultural production by households, %.

$$E_3 = \phi(e_{10}, e_{27}, e_{28}, e_{11}, e_{12}, e_{13}, e_{15}, e_{16}, e_{17}, e_{18}, e_{19}, e_{20}, e_{21}, e_{22}, e_{23}, e_{24}, e_{25}, e_{26}), \quad (5)$$

where e_{10} is the profitability of rural producers, %; e_{27} – financial results from ordinary activities before taxation per 1 person, thousand UAH; e_{28} – profit per 1 person, thousand UAH; e_{11} – indicator of employment in the agricultural sector, %; e_{12} – average monthly wage of agricultural producers, UAH; e_{13} – agricultural production per 1 person, thousand UAH; e_{15} – share of crop production, %; e_{16} – share of livestock products, %; agricultural production per 1 person, kg: e_{17} – cereals and legumes; e_{18} – sugar beet; e_{19} – sunflower; e_{20} – potatoes; e_{21} – vegetable crops; e_{22} – fruit and berry crops; e_{23} – meat (in slaughter weight); e_{24} – milk; e_{25} – eggs, pcs.; e_{26} – volume of products sold by agricultural producers per 1 person, thousand UAH.

$$E_4 = \phi(e_{29}, e_{30}), \quad (6)$$

where e_{29} is the volume of capital investments in agriculture per 1 person, thousand UAH; e_{30} – share of capital investments in the agricultural sector to total, %.

The block of social indicators of rural development tentatively structured by the following factor groups:

- ▶ level of demographic situation S_1 ;
- ▶ rural employment rate S_2 ;
- ▶ education level S_3 ;
- ▶ level of rural infrastructure development S_4 ;
- ▶ level of population welfare S_5 ;
- ▶ quality of life of the rural population S_6 .

Mathematically, the variable social component is represented as follows:

$$IR_s = \phi(S_1, S_2, S_3, S_4, S_5, S_6). \quad (7)$$

The mathematical tools for identifying the structural components that form the social block of factors influencing the development of rural areas of ATCs are presented as follows:

$$S_1 = \phi(s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_{13}, s_{14}, s_{15}, s_{16}, s_{17}), \quad (8)$$

where s_1 is the total population of the ATC, thousands people; s_2 – share of the rural population, %; s_3 – average number of residents in 1 village, people; s_4 – the dynamics of the rural population per 1,000 people; s_5 – total fertility rate per 1 woman; s_6 – is the rural fertility rate, people; s_7 – is the rural mortality rate; s_{13} – number of registered marriages, units; s_{14} – per 1,000 population; s_{15} – number of registered divorces; s_{16} – per 1,000 population; s_{17} – ratio of marriages and divorces rates.

$$S_2 = \phi(s_8, s_{10}, s_{11}, s_9, s_{12}), \quad (9)$$

where s_8 is the economically active rural population (age group 15-70), thousands of people; s_9 – economically inactive rural population (age group 15-70), thousands of people; s_{10} – economic activity indicator, %; s_{11} – employment rate, %; s_{12} – unemployment rate, %.

$$S_3 = \phi(s_{18}, s_{19}, s_{20}, s_{21}, s_{22}, s_{23}, s_{24}, s_{25}, s_{26}, s_{27}), \quad (10)$$

where s_{18} is the percentage of children with kindergartens, %; s_{19} – in urban-type settlements, %; s_{20} – in villages, %; s_{21} – indicator of kindergartens provision per 100 places, %; s_{22} – in urban-type settlements; s_{23} – in the villages; s_{24} – number of people enrolled in educational institutions, thousands of people; s_{25} – in secondary education institutions; s_{26} – in vocational and technical education institutions; s_{27} – in higher education institutions.

$$S_4 = \phi(s_{28}, s_{29}, s_{30}), \quad (11)$$

where s_{28} – the number of libraries per 1 rural settlement, units; s_{29} – the number of club per 1 rural settlement, units; s_{30} – number of hospital beds per 10,000 thousand people, units.

$$S_5 = \phi(s_{31}, s_{32}, s_{33}), \quad (12)$$

where s_{31} is the consumer price index; s_{32} – average aggregate total monthly income of a rural household, UAH; s_{33} – the share of consumption of own subsidiary farm products in rural areas, %.

$$S_6 = \phi(s_{34}, s_{35}, s_{36}, s_{37}, s_{38}, s_{39}), \quad (13)$$

where s_{34} is the indicator of housing provision, m² per person; s_{35} – indicator of provision of dwellings in rural areas with water supply, %; s_{36} – is the indicator of hot water supply; s_{37} – is the indicator of sewerage; s_{38} – is the indicator of central heating; s_{39} – is the indicator of natural gas.

The last environmental factor component of the model of effective rural development is structured into two blocks – the level of atmospheric air and land resources Ek_1 and the level of investment support for environmental protection Ek_2 .

The mathematical description of the environmental block for the development of rural areas of the ATC is presented in the form of the following formula:

$$IR_{ek} = \phi(Ek_1, Ek_2). \quad (14)$$

The block of environmental indicators of rural development is indicatively structured by the following factor groups.

The factor groups that structurally form the environmental component of the impact on the level of rural development will be presented using the following mathematical tools.

$$Ek_1 = \phi(ek_1, ek_2, ek_3, ek_6, ek_7), \quad (15)$$

where ek_1 – emissions of harmful substances that pollute the atmosphere as a result of the functioning of sectoral components of agricultural production, % of total harmful emissions; ek_2 – emissions of carbon dioxin into the

atmosphere as a result of the functioning of sectoral components of agricultural production, % of total harmful emissions; ek_3 – indicator of the level of forest reproduction (ratio of planting areas to the volume of deforestation), %; ek_6 – share of fertilised area with organic fertilisers, %; ek_7 – share of fertilised area with mineral fertilizers, %.

$$Ek_2 = \phi(ek_4, ek_5), \quad (16)$$

where ek_4 is the level of investment activity of capital investments in environmental protection, % of total capital investments in agriculture development; ek_5 – the level of current investment activity in environmental protection, % of total capital investments.

The next stage of the algorithm for substantiating a variable model for enhancing the development of rural areas of ATCs is the structured formation of appropriate arrays of calculation indicators for each block of factors. The indicators are calculated for each indicator in the retrospective of the study by dividing them by the maximum value using the following formulas:

$$ne_{ij} = \frac{e_{ij}}{e_{maxij}}, \quad (17)$$

where ne_{ij} is the calculated indicator of the i-th indicator of the economic block in the j-th year.

$$ns_{ij} = \frac{s_{ij}}{s_{maxij}}, \quad (18)$$

where ns_{ij} is the calculated indicator of the i-th indicator of the social block in the j-th year.

$$nek_{ij} = \frac{ek_{ij}}{ek_{maxij}}, \quad (19)$$

where nek_{ij} is the calculated indicator of the i-th indicator of the environmental block in the j-th year.

It was used the arithmetic mean values for each calculated indicator for further modelling. Accordingly, the further tools for calculating the values of the indicators of rural development of ATCs according to the selected indicative structuring of factor groups are as follows (Table 1).

Table 1. Toolkit for calculating rural development indicators of ATCs by factor groups

Function of factor groups of indicators	Calculation formula
Block of economic indicators	
$E_1 = \phi(e_1, e_2, e_3, e_4)$	$E_1 = \sqrt[5]{\prod_{i=1}^5 ne_{imv}}$
$E_2 = \phi(e_6, e_7, e_8, e_9, e_{14})$	$E_2 = \sqrt[5]{\prod_{i=1}^5 ne_{imv}}$
$E_3 = \phi(e_{10}, e_{27}, e_{28}, e_{11}, e_{12}, e_{13}, e_{15}, e_{16}, e_{17}, e_{18}, e_{19}, e_{20}, e_{21}, e_{22}, e_{23}, e_{24}, e_{25}, e_{26})$	$E_3 = \sqrt[18]{\prod_{i=1}^{18} ne_{imv}}$
$E_4 = \phi(e_{29}, e_{30})$	$E_4 = \sqrt[2]{\prod_{i=1}^2 ne_{imv}}$
Block of social indicators	
$S_1 = \phi(s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_{13}, s_{14}, s_{15}, s_{16}, s_{17})$	$S_1 = \sqrt[12]{\prod_{i=1}^{12} ns_{imv}}$
$S_2 = \phi(s_8, s_{10}, s_{11}, s_9, s_{12})$	$S_2 = \sqrt[5]{\prod_{i=1}^5 ns_{imv}}$
$S_3 = \phi(s_{18}, s_{19}, s_{20}, s_{21}, s_{22}, s_{23}, s_{24}, s_{25}, s_{26})$	$S_3 = \sqrt[9]{\prod_{i=1}^9 ns_{imv}}$

Table 1, Continued

Function of factor groups of indicators	Calculation formula
$S_4 = \phi(s_{28}, s_{29}, s_{30})$	$S_4 = \sqrt[3]{\prod_{i=1}^3 n s_{imv}}$
$S_5 = \phi(s_{31}, s_{32}, s_{33})$	$S_5 = \sqrt[3]{\prod_{i=1}^3 n s_{imv}}$
$S_6 = \phi(s_{34}, s_{35}, s_{36}, s_{37}, s_{38}, s_{39})$	$S_6 = \sqrt[6]{\prod_{i=1}^6 n s_{imv}}$
Block of environmental indicators	
$Ek_1 = \phi(ek_1, ek_2, ek_3, ek_6, ek_7)$	$Ek_1 = \sqrt[5]{\prod_{i=1}^5 n e k_{imv}}$
$Ek_2 = \phi(ek_4, ek_5)$	$Ek_2 = \sqrt[2]{\prod_{i=1}^2 n e k_{imv}}$

Source: developed by the authors

The next stage of the modelling algorithm is the process of streamlining the set of calculated indicators by constructing maps of the values of the relevant economic, social and environmental indicators of rural

development of the ATCs of Vinnytsia region. Accordingly, to rank arrays of indicators by economic, social and environmental blocks, it is advisable to use the following evaluation scale (Table 2).

Table 2. Ranking tools for rural development indicators in ATCs

Scoring limits	Characteristics of the level of rural development
0.000-0.300	Critical level
0.301-0.500	Threatening level
0.501-0.700	Satisfactory growth rates
0.701-0.900	Optimum growth rates
0.901-1.000	High level of development

Source: developed by the authors

The empirical basis of the study is the data of the Main department of statistics in Vinnytsia region (n.d.), Official website of the State Statistics Service of Ukraine (n.d.), information materials of Strategy of balanced regional development of the Vinnytsia region until 2027 (2024).

► Results and Discussion

The results of the practical development of the proposed methodological tools are the following array of fuzzy data transformed into calculated indicators of rural development by economic block (Table 3).

Table 3. Dynamics of economic calculation indicators of rural development of ATCs in Vinnytsia region, 2017-2022

Characteristics of the indicators	Indicator designation	2017	2018	2019	2020	2021	2022	e_{mv}
<i>Level of land availability</i>								
Total land area per 1 person, ha;	e_1	0.961	0.970	0.980	0.989	1.000	0.973	0.979
Area of agricultural land per 1 person; ha,	e_2	0.962	0.970	0.979	0.989	1.000	0.972	0.979
Level of agricultural land development; %,	e_3	1.000	0.999	0.999	0.999	0.999	0.999	0.999
Ploughed rate of agricultural land, %;	e_4	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Indicator of agricultural land availability, ha per one rural resident.	e_5	0.954	0.968	0.982	1.000	0.975	0.957	0.973
<i>Level of entrepreneurial activity in rural areas</i>								
Number of agricultural enterprises per 10,000 population, units	e_6	0.784	0.838	0.892	0.851	0.784	0.830	0.830
Share of small enterprises, %	e_7	0.996	0.992	0.987	0.987	1.000	0.992	0.992
Number of enterprises and other registered participants in the agricultural sector, units	e_8	0.918	0.897	0.892	0.868	0.829	0.881	0.881
Share of the total amount, %	e_9	0.917	0.889	0.875	0.847	0.847	0.868	0.874
Share of agricultural production by households, %	e_{14}	1.000	0.891	0.830	0.894	0.762	0.823	0.867
<i>Level of efficiency of the organisational and economic mechanism of management</i>								
Profitability of rural producers, %	e_{10}	0.572	0.439	0.233	0.364	1.000	0.534	0.524
Indicator of employment in the agricultural sector, %	e_{11}	0.915	0.933	0.965	1.000	0.927	0.921	0.943

Table 3, Continued

Characteristics of the indicators	Indicator designation	2017	2018	2019	2020	2021	2022	e_{mv}
Average monthly wage of agricultural producers, UAH	e_{12}	0.530	0.679	0.833	0.873	0.972	1.000	0.815
Agricultural production per 1 person, thousand UAH	e_{13}	0.827	0.923	0.942	0.810	1.000	0.817	0.887
Share of crop production, %	e_{15}	0.976	1.000	0.921	0.858	0.958	0.981	0.949
Share of livestock products, %	e_{16}	0.763	0.714	0.845	1.000	0.798	0.752	0.812
Agricultural production per 1 person, kg:								
Cereals and legumes	e_{17}	0.726	0.887	0.899	0.614	1.000	0.556	0.780
Sugar beet	e_{18}	0.891	1.000	0.625	0.648	0.746	0.777	0.781
Sunflower	e_{19}	0.716	0.805	0.852	0.786	1.000	0.778	0.823
Potatoes	e_{20}	0.960	0.981	0.948	1.000	0.836	0.934	0.943
Vegetable crops	e_{21}	0.930	0.896	0.893	0.854	1.000	0.993	0.928
Fruit and berry crops	e_{22}	0.698	1.000	0.712	0.675	0.835	0.718	0.773
Meat (in slaughter weight)	e_{23}	0.462	0.513	0.677	0.703	0.700	1.000	0.676
Milk	e_{24}	1.000	0.978	0.914	0.883	0.829	0.778	0.897
Eggs, pcs.	e_{25}	0.993	0.973	1.000	0.940	0.767	0.668	0.890
Volume of products sold by agricultural producers per 1 person, thousand UAH.	e_{26}	0.542	0.629	0.678	0.638	1.000	0.751	0.706
Financial results from ordinary activities before taxation per 1 person, thousand UAH	e_{27}	0.297	0.276	0.193	0.159	1.000	0.397	0.387
Profit per 1 person, thousand UAH	e_{28}	0.316	0.320	0.221	0.248	1.000	0.526	0.438
<i>Level of investment attractiveness and activity</i>								
Volumes of capital investments in agriculture per 1 person, thousand UAH	e_{29}	0.954	1.000	0.836	0.633	0.672	0.905	0.833
Share of capital investments in the agricultural sector to total, %	e_{30}	1.000	0.689	0.645	0.560	0.576	0.807	0.713

Source: calculated by the authors according to the Main department of statistics in Vinnytsia region. (n.d.)

It was determined that the level of development of rural territories of the ATCs of Vinnytsia region is identified as high according to the average calculated indicators in the factor group "Level of provision with land resources". Thus, all component indicators of this group exceed the level of 0.900. The typology of rural development by the level of entrepreneurial activity in rural areas of the region is generally recognised as optimal. Almost all indicators that form this factor group by economic block are in the range of 0.830-0.881. The only exception is the indicator of the share of small enterprises; the calculated indicator is 0.992 and corresponds to a high level of rural development.

The indicators that form the factor group "The level of effectiveness of the organisational and economic mechanism of management" in their majority, also meet the

limits of the optimal development rates, which once again confirms that the agricultural sector of economy of Vinnytsia region' has been and remains one of the most powerful components of the agrarian potential of country. The exception from the entire array of normalised indicators of this factor group is indicators of financial results from ordinary activities and net profit per person – 0.387 and 0.438, respectively.

In terms of the total volume of capital investments in agriculture in the Vinnytsia region, the level of rural development can be defined as optimal, and in terms of the dynamics of the share of investments in the agrarian sector of the economy – as satisfactory. The above trends are demonstrated on the corresponding map of economic indicators of rural development in the Vinnytsia region's ATCs (Fig. 1).

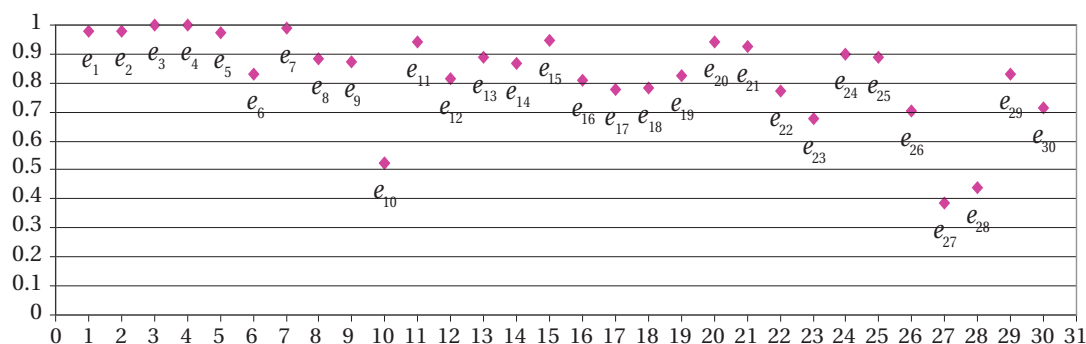


Figure 1. Map of values of indices of economic indicators of rural development of ATCs in Vinnytsia region

Source: compiled by the authors

Thus, it is clearly shown most economic indicators correspond to the typology of the optimal level of rural development. It is determined that the overall indicator of the rural development for the economic block is 0.849, but the values for the factor groups of the economic block vary

from a minimum of 0.756 (E_3) to a maximum of 0.986 (E_1) (Table 4). Based on the research and the existing dynamics of the calculated values of economic indicators, a monitoring rating of priority problems of rural development that need to be addressed has been formed.

Table 4. Indicative structuring of the economic problems of rural development in the Vinnytsia region

Name and code of the structural indicator	Indicator code	Monitoring rating of priority problems of rural development
Level of land availability E_1 0.986	e_1	The need to introduce an effective mechanism for the economic use of land
	e_2	
	e_5	Availability of agricultural land in the territories
	e_3	The need to introduce the mechanisms for an effective land use system
	e_4	Ensuring an appropriate level of agro technological discipline and improving soil fertility
Level of entrepreneurial activity in rural areas E_2 0.905	e_6	Ensuring effective regulation of rural entrepreneurship
	e_7	Increasing the liberalisation of the socio-economic policy for small and medium-sized agribusiness in the rural areas
	e_8	Introduce effective mechanisms for cooperation between government and business
	e_9	Activation of the business environment
	e_{14}	Legal regulation and development of mechanisms of entrepreneurial activity of the rural population
Level of investment attractiveness and activity E_4 0.771	e_{29}	Creating a favourable investment climate
	e_{30}	Implementation of investment projects aimed at ensuring the production of high added products
Level of efficiency of the organisational and economic mechanism of management E_3 0.756	e_{10}	Implementation of effective mechanisms for managing the economic activity of rural commodity producers
	e_{27}	Increasing the financial capacity of communities
	e_{28}	Implementation of areas of empowerment in the process of community resource management
	e_{11}	Ensuring employment of the rural population
	e_{12}	Introduction of the policy of stable growth of living standards of the rural population
	e_{13}	Increasing the level of innovative development of rural producers
	e_{15}	Structural optimisation of sectoral production in the agricultural sector
	e_{16}	
	e_{17}	Stabilisation of production and gradual increase in agricultural output and sales
	e_{18}	
	e_{19}	
	e_{20}	
	e_{21}	
	e_{22}	
	e_{23}	
	e_{24}	
	e_{25}	
	e_{26}	
		Ensuring that agricultural enterprises enter the foreign market
		Development of organic production and markets for the niche crops
		Implementation of effective mechanisms for resource, technological and innovative support of agricultural producers

The overall rural development indicator for the economic block is 0.849

Source: developed by the authors

It is quite clear that if one practically understand and consider the mechanism of development of the rural territories of ATCs through the plane of the identified indicators, the algorithm of prioritisation of solving economic problems should gradually move from the index with the lowest value to the highest. Based on the definition of an array of indicators, systematisation and calculation of structural indicators, the priority of economic problems of rural development in the ATCs of Vinnytsia region can be presented as follows (Fig. 2).

Thus, the starting point for achieving the strategic goals of optimal rates of rural development is the priority improvement of the investment climate, followed by the development and implementation of measures aimed at improving the efficiency of the organisational and economic mechanism of economic activity of all ATCs. It is worth noting that the financial capacity of communities is strongly mediated by the activity and efficiency of business entities operating on their territory, which are the main taxpayers to local budgets. Therefore, further

activation of the business environment of ATCs is one of the key aspects of solving the problems of rural development.

In turn, the policy of minimising the economic problems of rural development in ATCs is impossible without

improving the mechanisms of resource use, optimising land use and land relations. A similar algorithmic scenario was used to model and identify social problems of rural development.



Figure 2. Structural and logical sequence of the policy of minimisation economic problems of rural development in ATCs of Vinnytsia region

Source: compiled by the authors

Practical testing of the proposed methodological modelling tools allowed us to form the following array of fuzzy data, which was transformed into dynamic series of rural development indicators by social block (Table 5). The calculations have established that, according to the factor group “level of the demographic situation”, the level of development of the rural territories of the ATCs of Vinnytsia region is identified as optimal according to the average calculated indicators.

However, there is considerable variability in the components of the indicators of this group. Thus, the population indicators of the region's ATCs meet the characteristics of a high level development, but the estimated indicators of population growth, fertility and mortality are identified as satisfactory. The typology of rural development by the level of employment of the rural population of the Vinnytsia region's ATCs is generally recognised as optimal.

Table 5. Dynamics of social calculated indicators of rural development of ATCs in Vinnytsia region, 2017-2022

Characteristics of the indicators	Indicator designation	2017	2018	2019	2020	2021	2022	s_{mv}
<i>Level of demographic situation</i>								
Total population of the ATC, thousands people	s_1	0.978	0.969	0.960	0.950	0.940	0.954	0.959
Share of the rural population, %	s_2	0.918	0.912	0.908	0.903	0.895	0.906	0.907
Average number of residents in 1 village, people	s_3	0.794	0.783	0.773	0.760	0.746	0.769	0.771
Dynamics of the rural population per 1,000 people	s_4	0.768	0.696	0.679	0.670	0.548	0.620	0.664
Total fertility rate per 1 woman	s_5	0.853	0.794	0.758	0.757	0.714	0.754	0.772
Rural fertility rate, people	s_6	0.807	0.717	0.664	0.653	0.629	0.674	0.691
The rural mortality rate	s_7	0.859	0.841	0.841	0.824	0.777	0.807	0.825
Number of registered marriages, units	s_{13}	0.774	0.724	0.761	0.514	0.659	0.654	0.681
Per 1,000 population	s_{14}	0.750	0.713	0.750	0.513	0.663	0.648	0.673
Number of registered divorces	s_{15}	0.690	0.602	0.669	0.776	0.745	0.701	0.697
Per 1,000 population	s_{16}	0.676	0.575	0.639	0.742	0.697	0.667	0.666
Ratio of marriages and divorces rates	s_{17}	0.739	0.609	0.739	0.565	0.696	0.646	0.666
<i>Rural employment rate</i>								
Economically active rural population (age group 15-70), thousands of people	s_8	0.732	0.749	0.761	0.781	0.784	0.762	0.761
Economically inactive rural population (age group 15-70), thousands of people	s_9	0.708	0.722	0.733	0.765	0.765	0.734	0.738
Economic activity indicator, %	s_{10}	0.797	0.812	0.827	0.849	0.845	0.824	0.826
Employment rate, %	s_{11}	0.814	0.830	0.841	0.847	0.854	0.829	0.836
Unemployment rate, %.	s_{12}	0.652	0.674	0.682	0.580	0.617	0.599	0.634
<i>Education level</i>								
Percentage of children with kindergartens, %	s_{18}	0.817	0.841	0.866	0.878	0.854	0.852	0.851
In urban-type settlements, %	s_{19}	0.887	0.907	0.959	0.979	0.969	0.945	0.941
In villages, %	s_{20}	0.627	0.640	0.640	0.653	0.613	0.629	0.634
Indicator of kindergartens provision per 100 places, %	s_{21}	1.000	0.991	0.937	0.910	0.847	0.920	0.934
In urban-type settlements	s_{22}	1.000	1.000	0.933	0.904	0.859	0.925	0.937
In the villages	s_{23}	0.848	0.828	0.788	0.768	0.677	0.761	0.778

Table 5, Continued

Characteristics of the indicators	Indicator designation	2017	2018	2019	2020	2021	2022	s_{mv}
Number of people enrolled in educational institutions, thousands of people	s_{24}	0.794	0.806	0.802	0.832	0.777	0.800	0.802
In secondary education institutions	s_{25}	0.691	0.710	0.723	0.732	0.730	0.720	0.718
In vocational and technical education institutions	s_{26}	0.682	0.641	0.601	0.591	0.616	0.628	0.627
In higher education institutions	s_{27}	0.806	0.801	0.743	0.706	0.589	0.711	0.726
<i>Level of rural infrastructure development</i>								
The number of libraries per 1 rural settlement, units	s_{28}	0.572	0.571	0.570	0.567	0.565	0.543	0.564
The number of club per 1 rural settlement, units	s_{29}	0.686	0.685	0.672	0.685	0.664	0.644	0.673
Number of hospital beds per 10,000 thousand people, units	s_{30}	0.857	0.825	0.818	0.783	0.751	0.709	0.790
<i>Level of population welfare</i>								
The consumer price index	s_{31}	0.876	0.908	0.967	0.962	0.911	0.796	0.903
Average aggregate total monthly income of a rural household, UAH	s_{32}	0.598	0.632	0.890	0.894	0.977	0.829	0.803
The share of consumption of own subsidiary farm products in rural areas, %	s_{33}	0.913	0.913	0.722	0.722	0.713	0.790	0.795
<i>Quality of life of the rural population</i>								
The indicator of housing provision, m ² per person	s_{34}	0.896	0.908	0.924	0.941	0.949	0.927	0.924
Indicator of provision of dwellings in rural areas with water supply, %;	s_{35}	0.254	0.268	0.276	0.283	0.287	0.276	0.274
indicator of hot water supply	s_{36}	0.282	0.284	0.291	0.291	0.296	0.290	0.289
indicator of sewerage	s_{37}	0.310	0.320	0.332	0.337	0.337	0.329	0.327
indicator of central heating	s_{38}	0.573	0.584	0.584	0.586	0.583	0.582	0.582
indicator of natural gas	s_{39}	0.854	0.856	0.863	0.863	0.861	0.860	0.860

Source: calculated by the authors according to the Main department of statistics in Vinnytsia region. (n.d.)

Most of the indicators that structurally form this group of indicators are in the range of 0.738-0.836. As expected, the calculated value of the unemployment rate was much lower – 0.634, which corresponds to a satisfactory level of development. The factor group of social indicators of rural development “level of education” corresponds to the optimal type of rural development, both in terms of preschool and school education and all levels of vocational education.

The indicators that form the factor group “Level of population welfare” also correspond to the values of optimal development rates and in the range of 0.795-0.903. According to the indicators of the quality of life of the population, the level of development of the ATCs rural areas can only be identified as threatening. The indicators of water supply and sewerage in rural areas remain extremely low – 0.274 and 0.327, which generally corresponds to a critical level of rural development. According to indicators of the

state of rural infrastructure, the level of development of the rural territories of the Vinnytsia Region can be identified as satisfactory (calculated indicators in the range of 0.564-0.790). Relevant trends in the dynamics and average values of social indicators of the rural development in the Vinnytsia Region's ATCs are shown on the corresponding map (Fig. 3). The map of values shows that the vast majority of social indicators correspond to the typology of satisfactory and optimal level of development. The calculations have established that the integral indicator of rural development for the social block is 0.702, but the values for the factor groups of the social block vary from a minimum of 0.490 (S_6) to a maximum of 0.828 (S_5). Thus, 4 of the 6 factor groups of social indicators correspond to the optimal level of development (S_1 , S_2 , S_3 and S_5), the level of development of rural areas is recognised as satisfactory, and according to the quality of life indicators (S_6) – as threatening.

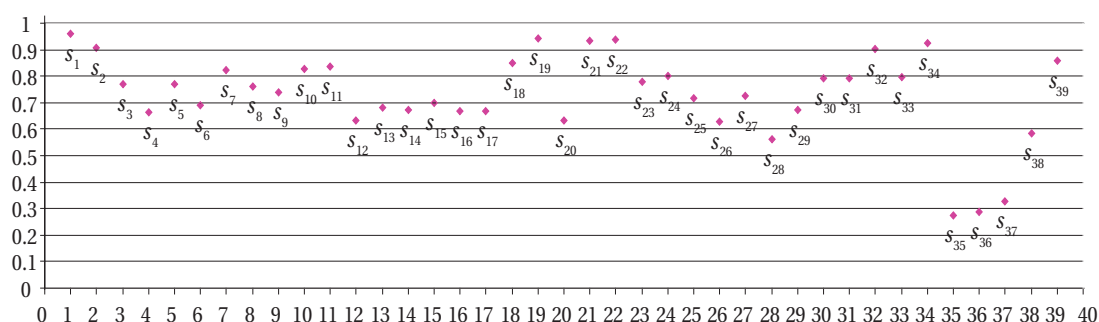


Figure 3. Map of values of social indicators of rural development in the Vinnytsia region's ATCs

Source: compiled by the authors

The monitoring rating of priority social problems of rural development that need to be addressed can be presented as follows (Table 6). Based on the practical implementation of the algorithmic stages of systematisation

and calculation of structural indicators, the priority of solving social problems of rural development in ATCs of Vinnytsia region can be presented in the following sequence (Fig. 4).

Table 6. Indicative structuring of social problems of rural development in ATCs of Vinnytsia region

Name and code of the structural indicator	Indicator code	Monitoring rating of priority problems of rural development
Level of demographic situation S_1 0.742	S_1	Implementation of measures to preserve the number of rural population
	S_2	Reduction of territorial disparities in population by increasing the accessibility of social infrastructure facilities for rural residents
	S_3	
	S_4	Developing a socio-economic policy to promote fertility and optimise solutions to the problem of rural population ageing
	S_5	
	S_6	Socio-economic measures to reduce mortality and extended life expectancy of the rural population
	S_{13}	
	S_{14}	
	S_{15}	Implementation of the policy of promoting family development
	S_{16}	
	S_{17}	
Rural employment rate S_2 0.755	S_8	Developing a favourable business environment to increase rural employment
	S_{10}	Gradual expansion of employment areas
	S_{11}	Promoting self-employment in the services, retail and other sectors
	S_9	Implementation of measures to address socio-economic problems and minimise unemployment
	S_{12}	
Education level S_3 0.787	S_{18}	
	S_{19}	
	S_{20}	Implementation mechanisms to improve the efficiency of the education network
	S_{21}	
	S_{22}	Ensuring that canteens in rural schools meet HASSP requirements
	S_{23}	Modernisation of the heating system in educational institutions
	S_{24}	Improving the level of bomb shelters in educational institutions
	S_{25}	Solving the problem of physical and moral deterioration of technical elements of rural schools and other educational institutions
	S_{26}	Reducing of inter-district imbalances in education development
	S_{27}	
Level of rural infrastructure development S_4 0.669	S_{28}	Improvement of the transport system and road infrastructure
	S_{29}	Reducing inter-regional imbalances in the health care and culture development
	S_{30}	Strengthening the equipment of medical institutions with modern medical equipment Strengthening the material and technical support of cultural institutions
Level of population welfare S_5 0.828	S_{31}	Implementation of effective measures to overcome the problem of poverty and strengthen social protection
	S_{32}	Raising the income level of the rural population
	S_{33}	Optimisation of the system of state aid to military families and vulnerable groups
Quality of life of the rural population S_6 0.490	S_{34}	
	S_{35}	
	S_{36}	Solving the problem of housing supply
	S_{37}	Development of communal infrastructure in local communities
	S_{38}	
	S_{39}	
The overall rural development indicator for the social block is – 0.702		

Source: developed by the authors

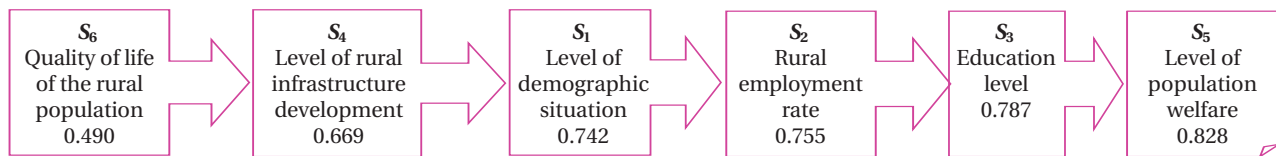


Figure 4. Structural and logical sequence of the policy of minimising social problems of rural development in the Vinnytsia region

Source: compiled by the authors

Based on the modelling, it is considered it appropriate to state that the achievement of the strategic goals of rural development in the social bloc requires constant work aimed at the formation and further development of rural infrastructure, the development of effective mechanisms for increasing the level of income and population

quality life, improving social protection, quality of education and stabilising the demographic situation of the region's ATCs. According to the proposed modelling algorithm, the calculated array of fuzzy data characterising the level of rural development according to environmental criteria is presented in Table 7.

Table 7. Dynamics of environmental calculation indicators of rural development of ATCs in Vinnytsia region, 2017-2022

Characteristics of the indicators	Indicator designation	2017	2018	2019	2020	2021	2022	ek_{mv}
<i>Level of atmospheric air and land resources</i>								
Emissions of harmful substances that pollute the atmosphere as a result of the functioning of sectoral components of agricultural production, % of total harmful emissions	ek_1	0.513	0.864	0.671	0.642	0.887	0.723	0.717
Emissions of carbon dioxin into the atmosphere as a result of the functioning of sectoral components of agricultural production, % of total harmful emissions	ek_2	0.696	0.889	0.471	0.464	0.508	0.560	0.598
Indicator of the level of forest reproduction (ratio of planting areas to the volume of deforestation), %	ek_3	0.851	0.846	0.583	0.509	0.629	0.667	0.681
Share of fertilised area with organic fertilizers, %	ek_6	0.300	0.300	0.650	0.583	0.650	0.481	0.494
Share of fertilised area with mineral fertilisers, %	ek_7	0.688	0.687	0.685	0.707	0.682	0.696	0.691
<i>Level of investment support for environmental protection</i>								
Level of investment activity of capital investments in environmental protection, % of total capital investments in agriculture development	ek_4	0.522	0.582	0.462	0.326	0.908	0.598	0.566
Level of current investment activity in environmental protection, % of total capital investments	ek_5	0.821	0.788	0.854	0.930	0.607	0.763	0.794

Source: calculated by the authors according to the Main department of statistics in Vinnytsia region. (n.d.)

It has been determined that the level of rural development of the ATCs of Vinnytsia region is identified as satisfactory to the factor group "Level of the state of atmospheric air and land resources" by the average calculated indicators. It should be noted that all the component indicators of this group are within the range of 0.494-0.717. In turn, the typology of the development of rural areas of the ATCs by the level of investment support for environmental protection is also recognised as satisfactory. Thus, the share of capital investments in environmental protection remains low and corresponds to a threatening level of de-

velopment. The above trends are illustrated on the corresponding map of environmental indicators (Fig. 5).

Thus, almost all environmental indicators correspond to the typology of a satisfactory level of rural development. It has been determined that the overall indicator of rural development for the environmental block is 0.650, and the values for the factor groups of the environmental block have a slight variation – 0.631(Ek_1) 0.670 (Ek_2). The corresponding monitoring rating of priority environmental problems that require gradual optimisation can be presented as follows (Table 8).

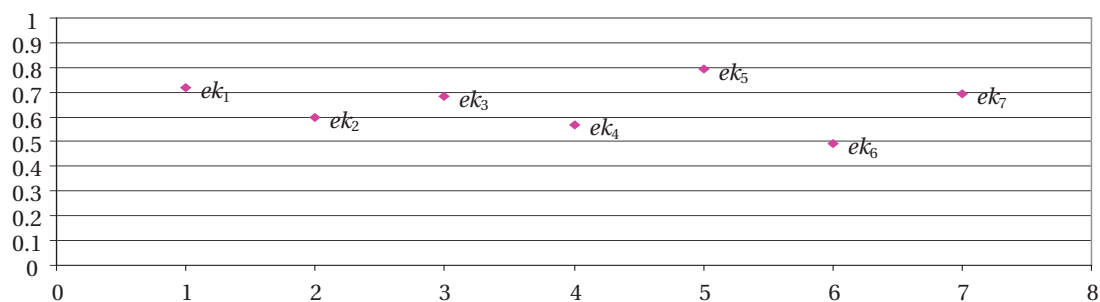


Figure 5. Map of the values of indices of environmental indicators of rural development of ATCs of Vinnytsia region
Source: compiled by the authors

Table 8. Indicative structuring of environmental problems of rural development in the ATCs of Vinnytsia region

Name and code of the structural indicator	Indicator code	Monitoring rating of priority problems of rural development
Level of atmospheric air and land resources Ek1 0.631	ek_1	Compliance with environmental requirements in the course of economic activity of rural producers
	ek_2	Reduction air pollution
	ek_3	Reducing the level of land and water pollution
	ek_6	Rationalisation of land use
	ek_7	Optimisation of economic and production use of agricultural lands
Level of investment support for environmental protection Ek2 0.670	ek_4	Introduce a policy of promote investment in environmental protection measures
	ek_5	
The overall rural development indicator for the environmental block is – 0.650		

Source: developed by the authors

Accordingly, the result of the final stage of modelling the intensification of rural development in Vinnytsia ATCs

according to environmental criteria is the following sequence of solving the identified problems (Fig. 6).

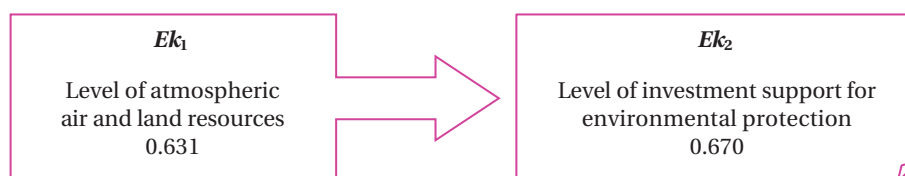


Figure 6. Structural and logical sequence of the policy of minimising environmental problems of rural development in the Vinnytsia region

Source: compiled by the authors

The development of the rural areas of ATCs is simply impossible without an effective solution to the environmental problems, the development of an effective regional policy to reduce air pollution, rationalisation of land use and the intensification of investment mechanisms aimed at environmental protection.

It is worth agreeing with the opinion of A. Sava (2018) that the methodological aspects of assessing the level of socio-economic development of rural areas and substantiating the priority directions of their development are identified with the selection of a set of relevant indicators, the application of methodological techniques for calculating integrated indicators and the corresponding construction of a rating of economic, social and environmental problems that need to be addressed. The objective practice of researching the level of rural development is not based on some stable, universal tools and algorithm. It has been established that scientific and practical

recommendations are developed and constantly improved, the main purpose of which is to optimise the processes of forming arrays of indicators and indicators in a differentiated way to substantiate specific projects, plans, programs and strategies.

Y. Ivanov *et al.* (2022) also focused on the development of methodological aspects of substantiating the directions of development of territorial communities. The methodological approach proposed by the authors is based on indicators of resource availability, management and financial capacity of communities and is an algorithm for the sequential development and practical testing of a set of methodological approaches: analysis of resource availability, implementation of priority problems and further development modelling based on the fuzzy set method.

It worth agreeing with the authors that the spatial development of territorial communities structuredly implies the availability of natural, production, labour and other

resources, the effective use of which leads to their stable functioning and gradual development. In turn, the justification, development and practical implementation of effective mechanisms for their effective use are the way to stable functioning and gradual development of rural areas. It is worth fully supporting the authors' opinion that the main drivers of the gradual and stable development of territorial communities are mechanisms of self-sufficiency, self-management and self-financing adapted and flexible to modern challenges of socio-economic realities.

I. Ksonzhyk *et al.* (2021) devoted their study to the practice of sustainable development of rural territorial communities in European countries. The authors focused their attention on practical concepts of development, investigated the relationship between the existing patterns of implementation of the principles and the final target indicators of the effectiveness of rural development and justified the model of their effective achievement. One can fully agree with the authors that the plane of scientific research in the prism of theoretical and methodological levers for substantiating the conceptual foundations of the development of territorial communities is objectively based on the synergistic trinity of economic, social and environmental indicators with the mandatory condition of applying a spectrum of innovations and energy technologies.

A significant contribution to the study of the problems of methodical substantiation of rural development prospects was made by Y. Liu *et al.* (2022), who substantiated theoretical and methodological assessment of the effectiveness of China's rural revitalization directions. The authors focused on the construction and definition of a set of indices to assess the effectiveness of rural revitalization strategies in China, differentiating them by factors affecting the quality of the material and spiritual life of the rural population.

F. Mantino (2021) studied the systematization of mechanisms explaining local and rural development in European countries. The author identified a tangible differentiation between the realities of local development in countries and the institutional vision of various international organizations and national (regional) authorities. It is worth supporting the author's research results, embodied in the proposed integrated theoretical and methodological approach, according to which local development processes are identified with the synergistic influence and interrelationship of three objective components – systems of local resources, networks, institutional support and enabling policy.

F. Poggi *et al.* (2018) link the realities of effective intensification of the development of rural areas in Portugal with the development and expansion of renewable energy. The authors methodically substantiated and practically determined the emergence of a functional dichotomy between the preservation of lands with a powerful agricultural potential and the practice of expanding sources and increasing the production of renewable energy in rural areas. It is worth agreeing that the adoption of management decisions aimed at ensuring efficient, balanced and ecologically economical management of agricultural production will be of strategic importance.

A. Veveris & A. Puzulis (2019) studied the significance role of the LEADER approach in rural development in

Latvia. The authors analysed the methodological and practical tools and quantitative results of the LEADER approach implementation in Latvia and other European countries for the period 2014–2020. The main conclusion is that this approach shows good results, contributes to the activation of local activities of rural communities and has strategic prospects in the future.

M. Flaga & M. Wesołowska (2018) studied the objective unfavourable socio-economic problems of the rural areas of the eastern regions of Poland. The authors determined the destructive impact of socio-demographic problems on the level of development of peripheral rural areas of Poland. The authors analysed changes in population growth and its components (natural movement and migration), population structure, as well as individual indicators of the quality and living conditions of residents. The result of the conducted research is the conclusion that the objective consequences of population change, the progressive aging of society, the decline of villages and social infrastructure have a negative impact on the future development of the region.

The results of Chinese researchers Z. Yin *et al.* (2021) are quite interesting for the methodology of enhancing rural development. The authors consider rural area from the perspective of a multifunctional approach as a natural, economic and social complex. The researchers calculated and characterised rural productive, living and environmental (PLE) functions at a grid scale of 300×300 m, and established a system of relevant assessment indices. The use of the ISO uncontrolled cluster classification tool allowed us to typify rural areas by the areas of further intensification of rural development: environmental protection, employment and residence, recreation and development potential. It is worth supporting the authors' opinion that the practical significance of the study can become a source of decision-making on the delimitation of rural production, life and environmental space and the development of spatial planning.

K. Tae-Hwa & Y. Seung-Ryong (2016) devoted their study to the methodological and practical aspects of the analysing the current state of rural development processes in Vietnam and substantiating the directions for its activation. In their study, the authors use the developed methodological tools – the construction of the Rural Development Index (RDI). It is worth agreeing with the authors that this methodical approach and the practical results of its implementation should be used to establish medium- and long-term visions and strategies for rural development policy in Vietnam.

M. Biczkowski (2020) devoted his research to the activation and substantiation of the possibilities of rural development of ATCs of Poland. As a methodological tool, the author used the LEADER approach and determined its impact on increasing the mobilisation of the existing resource potential of rural communities. The research has established that increasing the number of initiatives launched at the expense of the European Union, a combination of investment actions with social projects contributes to the intensification of rural development.

B. Hennebry & T. Strykiewicz (2020) devoted their study to the methodical justification and practical measurement of the existing differentiation in the level and

dynamics of rural development in two completely different countries – Austria and Portugal. As a methodological tool, the authors developed and proposed an index to measuring the “structural strength” of rural regions. The practical implementation of this theoretical and methodological approach allowed to build a rating of regions with weak rural development and identified a set of problems that need to be addressed. It is reasonable to agree with the authors that this index is a more holistic indicator of socio-economic development than the traditional gross domestic product (GDP) per capita.

The result of this study was the development and practical testing of a methodical approach to researching the process of socio-economic development of rural areas. Unlike the existing ones, this methodical approach comprehensively covers the algorithm for structuring the mathematical model of socio-economic effective development, which is based on the tools for calculating relevant indicators by factor groups, constructing the fields of their values, indicative structuring of priority problems and determining the sequence of their solution. Once a clear priority has been set for addressing economic, social and environmental problems, it is imperative to develop a strategic mechanism for rural development that can synergistically combine the relevant capabilities of public administration and local self-government.

► Conclusions

The conceptual result of the study is the formation of a variable model for enhancing the development of rural areas of the ATCs, based on the proposed methodological tools for structuring and identifying relevant economic, social and environmental indicators. In the course of mathematical transformation of arrays of fuzzy data characterizing the dynamics of economic, social and environmental components of rural development into comparable calculation indicators with their further structuring into factor groups, it is determined that the overall indicator of rural development in the economic block is 0.839. It has been

established that in terms of land resources provision, the level of development of rural territories of the ATCs of Vinnytsia region recognised as high with a mark of 0.986. By the level of entrepreneurial activity, investment attractiveness and efficiency of the organizational and economic mechanism of management, the development of rural areas of the region is identified as optimal with values of 0.905, 0.771 and 0.756, respectively.

The integral indicator of rural development for the social block is 0.702, which is on the verge of a satisfactory level. The determined values of the indicators by factor groups of the social block range from a minimum of 0.490 (quality of life of the rural population) to a maximum of 0.828 (level of well-being of the population). It was found that 54% of social indicators correspond to the optimal level of rural development, 33% – to the satisfactory, 8% – to the critical and threatening, and only 5% – to the high level. It was established that the environmental indicators correspond to the typology of the satisfactory level of rural development of ATCs with the level of the corresponding general indicator of 0.650.

The development and practical implementation of the proposed economic and mathematical model for modelling the strategic directions of rural development of the ATCs, taking into account economic, social and environmental factors, allows objectively assessing the problems of rural development of the Vinnytsia region and determining priorities for their solution. The results of the study contribute to the formation of algorithms for minimizing these problems and the justification of strategic directions for the activation of community development. This creates prerequisites for further research on the effectiveness of territorial transformations in rural areas.

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► Conflict of interest

None.

► References

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Методичні аспекти визначення стратегічних напрямів розвитку сільських територій об'єднаних територіальних громад

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► **Анотація.** Актуальність дослідження полягає в розробці економіко-математичної моделі для тактичного та стратегічного планування соціально-економічного розвитку сільських територій об'єднаних територіальних громад. Метою дослідження було вдосконалення та практичне застосування методичного інструментарію для визначення стратегічних напрямів розвитку сільських територій об'єднаних територіальних громад на прикладі Вінницької області. Було використано такі методи: порівняльного аналізу, статистичний, табличний, графічний, розрахунково-конструктивний, абстрактно-логічний. Запропонований методичний інструментарій та алгоритмізована послідовність його практичної реалізації дозволили визначити структурні та сукупні економічні, соціальні та екологічні індикатори розвитку сільських територій об'єднаних територіальних громад, змодельовати відповідний перелік пріоритетних проблем та обґрунтувати напрями їх мінімізації. Моделюванням стратегічних напрямів розвитку сільських територій на сукупності економічних, соціальних та екологічних факторів із використанням методичного інструментарію теорії нечітких множин встановлено, що загальний індикатор розвитку сільських територій за економічним блоком перебуває в межах оптимального темпу розвитку (0,849), за динамікою частки інвестицій в аграрний сектор економіки – перевищує задовільний рівень (0,771), за індикаторами фінансових результатів набуває загрозливого рівня (0,387). Встановлено, що інтегральний індикатор сільського розвитку за соціальним блоком знаходиться в межах задовільного темпу (0,702), а за показниками якості життя населення – загрозливого (0,490). Відповідно сформовано моніторинговий рейтинг першочергових соціальних проблем сільського розвитку, які потребують свого вирішення. Визначено, що за динамікою екологічних розрахункових індикаторів загальний індикатор за екологічним блоком перебуває в межах задовільного темпу розвитку сільських територій (0,650). Змодельовані рейтинги першочергових проблем сільського розвитку представлено у наступній послідовності політики їх мінімізації: економічних – E_4, E_3, E_2, E_1 ; соціальних – $S_6, S_4, S_1, S_2, S_3, S_5$; екологічних – Ek_1, Ek_2 . Практичні результати дослідження дозволяють об'єктивно оцінити переваги, виклики та ризики розвитку сільських територій ОТГ Вінницької області, що сприяє визначенню пріоритетів у вирішенні економічних, соціальних та екологічних проблем і може бути корисним у регіональній управлінській практиці для розробки стратегічних напрямів розвитку громад

► **Ключові слова:** економічні індикатори; соціальні індикатори; екологічні індикатори; інтегральний показник; варіативна модель; активізація розвитку сільських територій

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