

ISSN: 2221-1055
E-ISSN: 2413-2322

Національний науковий центр «Інститут аграрної економіки»
ТОВ «Наукові журнали»

ЕКОНОМІКА АПК

Науково-виробничий журнал

Заснований у 1994 році
Випускається 6 разів на рік

Том 30, № 5

Київ – 2023

ISSN: 2221-1055
E-ISSN: 2413-2322

Співзасновники:

Національний науковий центр «Інститут аграрної економіки»,
ТОВ «Наукові журнали»

Рік заснування: 1994

*Рекомендовано до друку та поширення
через мережу Інтернет Вченою радою
Національного наукового центру «Інститут аграрної економіки»
(протокол № 10 від 12 жовтня 2023 р.)*

**Свідectво про державну реєстрацію
друкованого засобу масової інформації**
серії KB № 25122-15062 ПР від 17 лютого 2022 р.

Журнал входить до Переліку наукових фахових видань України

Категорія «Б». Спеціальності: 051 «Економіка», 071 «Облік і оподаткування»,
072 «Фінанси, банківська справа та страхування», 073 «Менеджмент»,
076 «Підприємництво, торгівля та біржова діяльність»
(наказ Міністерства освіти і науки України від 11 липня 2019 р. № 975)

**Журнал представлено у міжнародних наукометричних базах даних,
репозитаріях та пошукових системах:** Google Scholar, Index Copernicus International,
Фахові видання України, Національна бібліотека України імені В. І. Вернадського, Crossref,
AGRIS, Econlit, ECONBIZ, Academic Resource Index ResearchBib, ZBW, WorldCat, JournalFinder,
EZB, SIS, GIF, InfoDase, PBN, CiteFactor, UBL, JIFACTOR, MIAR, TIB,
I2OR, General Impact Factor, BASE, ERIH PLUS, EBSCO, DOAJ

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03127, вул. Героїв Оборони, 10, м. Київ, Україна
E-mail: info@eapk.com.ua
www: <https://eapk.com.ua/uk>

ISSN: 2221-1055
E-ISSN: 2413-2322

National Scientific Center "Institute of Agrarian Economics"
LLC "Scientific Journals"

EKONOMIKA APK

Scientific and Production Journal

Founded in 1994
Published six times per year

Volume 30, No. 5

Kyiv – 2023

ISSN: 2221-1055
E-ISSN: 2413-2322

Co-founders:

National Scientific Center "Institute of Agrarian Economics",
LLC "Scientific Journals"

Year of foundation: 1994

*Recommended for printing and distribution
via the Internet by the Academic Council
of National Scientific Center "Institute of Agrarian Economics"
(Minutes No. 10 of October 12, 2023)*

**Certificate of state registration
of the print media**

Series KV No. 25122-15062 PR of February 17, 2022

Journal is included in the List of Scientific professional publications of Ukraine

Category "B". Specialty's: 051 "Economics", 071 "Accounting and Taxation",
072 "Finance, Banking and Insurance", 073 "Management",
076 "Entrepreneurship, Trade and Stock Market Activity"
(order of the Ministry of Education and Science of Ukraine of July 11, 2019, No. 975)

Journal is presented international scientometric databases, repositories

and scientific systems: Google Scholar, Index Copernicus International, Professional Publications
of Ukraine, Vernadsky National Library of Ukraine, Crossref, AGRIS, Econlit, ECONBIZ, Academic Resource
Index ResearchBib, ZBW, WorldCat, JournalFinder, EZB, SIS, GIF, InfoDase, PBN, CiteFactor, UBL, JIFACTOR,
MIAR, TIB, I2OR, General Impact Factor, BASE, ERIH PLUS, EBSCO, DOAJ

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UDC 330.3:631.1(477)

Investment activity in Ukrainian agriculture during the war: New challenges and threats

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► **Abstract.** Investment activity is an important condition for the effective functioning and development of the agricultural economy. Investments enable entrepreneurs to achieve the desired business results and complete their strategic goals. Since the beginning of Russia's invasion of Ukraine, agricultural producers have faced new challenges and threats, and have had to adapt to the new conditions. The purpose of this study was to investigate the impact of the war on Ukrainian agriculture and to identify new risks and dangers for investment activity in agriculture during the war. The study used the dialectical method of scientific cognition, analysis and synthesis, systematic generalisation, comparative analysis, as well as objective-historical, inductive, deductive methods, heuristic method of generating solutions, and the method of targeted substantiation. The study examined the trends in the development of investment activity in the agricultural sector of the Ukrainian economy in the pre-war period and during the war. The challenges and threats to agriculture caused by Russian aggression were identified. The study identified the main issues of investment activity of agricultural producers in the context of the full-scale invasion of the Russian Federation, suggested solutions to overcome these issues and vectors of support for agriculture during the war and in the post-war period of the country's recovery. The study considered the destructive processes in the system of functioning of the agrarian economy of Ukraine in the pre-war period and substantiated measures to overcome them. Priority areas of investment support to ensure sustainable development of the agrarian economy and rural areas were identified. The key guidelines for the development of the agricultural sector of the Ukrainian economy were substantiated. The conclusions, proposals, and practical recommendations can be used to develop corresponding programmes and measures aimed at supporting agricultural producers during the war and in the post-war period of national economic recovery

► **Keywords:** food security; risk; insecurity; financial support

► Introduction

The full-scale war with the Russian Federation has led to numerous challenges and threats that have affected Ukrainian agriculture. The war also exacerbated pre-war risks, which had an adverse impact on the investment activity of agricultural producers. A challenge is defined as a certain state of tension that arises within a system and cannot be resisted. Therefore, certain actions are required to avoid negative consequences due to the impact of certain challenges. In a broad sense, challenges can indicate the need for certain positive changes. A threat, on the other hand, is a real event in which a danger can become a reality. Many of today's food crises are linked to war and violent conflict. B. Kemmerling *et al.* (2022) developed

four aspects of war that affect food insecurity: a) destruction; b) conflict-induced displacement; c) food control; and d) famine as a "weapon of war".

Russia's military aggression has become the main negative factor affecting Ukraine's investment climate. The operating environment for agricultural enterprises has become substantially more difficult. Yu. Nikolchuk & O. Lopatovska (2023) investigated the issue of Ukraine's investment attractiveness and the search for ways to intensify investment activity during martial law. Investments are a key element of economic activity and an essential factor in the growth and development of both individual industries and the entire country. The problems of

► **Suggested Citation:** Matsybora, T. (2023). Investment activity in Ukrainian agriculture during the war: New challenges and threats. *Ekonomika APK*, 30(5), 10-18. doi: 10.32317/2221-1055.202305010.

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investing in the agricultural sector of Ukraine's economy have been the subject of research by many scholars who consider this process in various aspects and manifestations. M. Kryshtanovych (2020) studied the specific features of the development of investment activity in agriculture of Ukraine. He believes that an important way to increase the effectiveness of investment activity in agriculture is to stimulate innovation activity, which can be ensured by formulating an innovative economic policy at the state level.

I.O. Kryukova (2021), investigating investment trends in Ukrainian agriculture in the context of European practice, substantiates the importance of investing in innovation to improve the performance of agribusiness. Ensuring equal opportunities and conditions for investment activities for all categories of agricultural producers is an important condition for inclusive development of agriculture and rural areas. S. Stepanenko (2023) assesses the current state of investment support for business entities in the agrarian sector of the Ukrainian economy from the standpoint of the possibilities of ensuring their inclusive development. The level of investment in agriculture in Ukraine directly affects both national food and economic security and global food security. L. Artemenko *et al.* (2023) considered the problems of ensuring food security in Ukraine in the context of military aggression.

T. Ben Hassen & H. El Bilali (2022) studied the direct and indirect impact of the Russian-Ukrainian war on global food security. P. Berkhout *et al.* analysed the possible consequences of the war in Ukraine for food security in the short term. E. Krasznai Kovács *et al.* (2022) identified some of the immediate impacts and long-term challenges of the war in Ukraine on food security and production systems in Eastern Europe. K.A. Abay *et al.* (2023) find that while absolute food security may still be higher in rural areas where there are many poor households, urban poor people are likely to be most affected by the Russia-Ukraine war and the associated food price increases, especially in countries where social protection and food subsidies are unavailable.

In the context of the war, which is characterised by cruelty, large-scale destruction and loss of life, all business entities in Ukraine operate in a changing environment, constantly facing destructive factors. Uncertainty, unpredictability, insecurity, and instability in the environment give rise to new challenges, risks, and dangers. The purpose of this study was to assess the conditions of functioning of the agricultural business in Ukraine during the war, to identify problems affecting investment activity and to substantiate promising areas of agricultural development.

► Materials and Methods

The theoretical framework of this study included the research of Ukrainian and international scholars. The sources of information used in the study are statistical data from the State Statistics Committee of Ukraine (Economic statistics..., n.d.; Capital investments..., n.d.; Indexes of agricultural..., n.d.); information materials of the Ministry of Agrarian Policy and Food of Ukraine (Kherson plant for..., 2023; Only state sturgeon..., 2023), which contain reports on the consequences of the explosion of the Kakhovka hydroelectric power plant (HPP). The source of information on state support for the agro-industrial complex (AIC) in 2023 is the Law of Ukraine No. 2710-IX "On the State Budget of Ukraine for 2023" (2022).

The study used the results of a survey of foreign investors conducted by the Centre for Economic Strategy (The survey of foreign investors, 2019), a survey of 102 CEOs conducted by the European Business Association (Investment attractiveness index..., 2022), and a nationwide survey of 5200 rural households conducted by the Food and Agriculture Organization (FAO) of the United Nations (UN) (FAO, 2022). Furthermore, the study contains expert opinions (KSE Agrocenter, 2023). The study also used reliable sources of information on the Internet, including information on important events that took place in Ukraine during the war (Tarasovskyi, 2023; Murashko, 2023) and information on the amount of financial support for the development of the agricultural sector in 2023 (Support for agriculture..., 2023).

General scientific research methods were used to fulfil the purpose of this study and complete the tasks, including a more profound understanding of the problems of investment activity in agriculture in Ukraine during the full-scale war with the Russian Federation. The study is based on the application of the dialectical method of cognition of reality, which helps to consider agriculture in Ukraine in a systemic context. The use of this method helped to systematically analyse processes and phenomena in the agricultural sector, considering their interconnections and interdependencies. Using such theoretical research methods as observation, abstraction, analysis, comparison, and generalisation, the study reviewed the literature, analysed the world practices of agricultural producers, and the main vectors of agricultural, specifically investment, policy in the European Union and Ukraine. The comparison method helped to identify similarities and differences in opinions, approaches and practical actions regarding models of agricultural development, operating conditions, and support measures in Ukraine and other countries.

A comparative analysis of the economic performance of agricultural enterprises in different periods was used to find the cause-and-effect relationships in Ukrainian agriculture and to identify problems and challenges during the war, to establish regional imbalances and to outline trends in the development of investment activity in the agricultural sector. Using the objective historical method, the study found regularities in individual facts of the manifestation of the war in Ukraine and, on this basis, identified new challenges and dangers for agriculture.

Based on the analysis of theoretical and empirical results of the study of investment activity in agriculture in Ukraine in 2010-2022 and using the methods of analogy, comparison, and synthesis, the main provisions of the study were systematised, which became the basis for forming conclusions. The inductive method was used to summarise certain observations, facts, and specific features of agricultural activities in Ukraine during the war. The deductive method was used to identify the challenges and dangers in Ukrainian agriculture during the war as a result of building a logical chain of reasoning based on general information. Using the heuristic method of generating solutions and the method of targeted substantiation, practical recommendations were offered regarding the vectors of investment support for agriculture in Ukraine and ways of its development.

► Results and Discussion

Investment activities involve the investment of capital with the purpose of generating a profit, and therefore

always involve the risk of uncertainty of the final results of business activities, possible loss of capital or receipt of less than expected income. Due to the war in Ukraine caused by Russia, the external environment is becoming increasingly unpredictable, unstable, and volatile. Risks are rising, new challenges and threats are emerging, and there are dangers of losing not only business and wealth, but also health and life.

The investment climate of the country and its regions directly affects business and is a principal factor in investment. According to a survey of foreign investors, before the start of the full-scale war, the main obstacles to investment in Ukraine were massive corruption; lack of trust in the judiciary; monopolisation of markets; armed conflict with the Russian Federation; repressive actions of law enforcement agencies; financial instability and fluctuations in the foreign exchange market (The survey of foreign investors, 2019).

The full-scale war with Russia has become the main negative factor affecting Ukraine's investment climate and the investment attractiveness of agribusiness. In the first half of 2022 alone, the investment attractiveness index decreased by 0.56 points to 2.17 out of 5. This is the lowest value since 2013 (Investment attractiveness index..., 2022). Due to the occupation of certain regions, active hostilities, rocket attacks, logistical problems and blockades, soaring resource prices and a decline in incomes and purchasing power, the investment environment is becoming increasingly unfavourable and risky.

According to a survey of 102 CEOs conducted by the European Business Association, the main negative factors affecting Ukraine's investment climate include Russian military aggression, corruption, a weak judicial system, declining purchasing power, and logistical challenges (Investment attractiveness index..., 2022). The war caused considerable damage to Ukrainian agriculture. The

occupation of Ukrainian territories, mining and destruction of production facilities make it difficult and sometimes impossible for businesses to operate.

Agricultural land was damaged and contaminated, perennial plantations, machinery, and equipment were destroyed, farms were destroyed, and livestock was lost. As of 2023, 470 000 hectares of agricultural land in Ukraine were mined. Of the 17.5% of mined areas surveyed, 57 000 hectares are agricultural land. More than 2600 sappers from state and private companies are carrying out demining. With this capacity, it would take over 20 years to demine agricultural land alone (Murashko, 2023).

Furthermore, the suspension of processing plants caused problems with livestock feed and sales of agricultural raw materials. The activities of agricultural producers are hampered by damage to rural infrastructure and transport networks. Repairing the damage requires considerable financial investments, and at the same time, the impact of the war continues to operate, leading to long-term adverse consequences. According to a nationwide survey of 5200 rural households conducted by FAO, a quarter of respondents reported that they had suspended or reduced agricultural production due to the war. The trend is intensifying in areas close to the hostilities. In Sumy, Dnipro, Odesa, Chernihiv, and Mykolaiv oblasts, this figure exceeded 40% of rural households surveyed (FAO, 2022).

The war caused a sharp drop in production volumes. During the first year of the full-scale invasion, agricultural production in Ukraine fell by a quarter. Kherson, Zaporizhzhia, Donetsk, Luhansk, Kharkiv, Mykolaiv, and Odesa oblasts were the most affected. In the Kherson Oblast, where agricultural production decreased by 95.1% in 2022 compared to 2021, the situation is catastrophic. Only in Lviv and Zakarpattia oblasts did agricultural production increase slightly (Fig. 1).

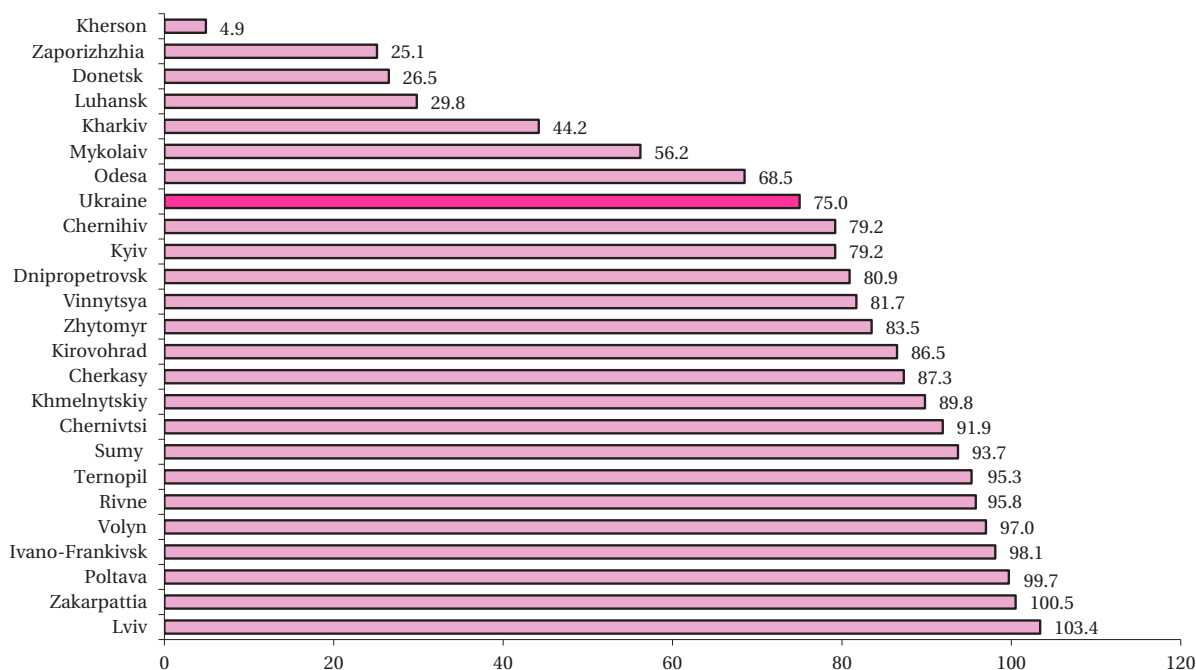


Figure 1. Agricultural production indices by region in 2022 (in constant 2016 prices; % of the previous year)

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: compiled from Economic statistics/Economic activity/Capital investment (n.d.)

The physical vulnerability of agricultural producers, the destroyed or damaged infrastructure, disrupted logistics, shortages of many inputs such as fertilisers, seeds, fuel, and their rising prices create other problems and dangers. Direct losses in Ukraine's agricultural sector since the beginning of the war as of 24 April 2023 amount to USD 8.7 billion, while indirect losses, including reduced crop and livestock production, logistics disruptions and increased production costs, amount to an additional USD 31.5 billion. Therefore, USD 29.7 billion is needed to cover the reconstruction and rehabilitation needs (KSE Agrocenter, 2023).

The largest share of agricultural producers' losses (USD 4.65 billion) is due to the destruction and damage of agricultural machinery. In total, 109 600 pieces of agricultural machinery were damaged or destroyed during the war. Damage from the destruction and theft of agricultural products is estimated at over USD 1.8 billion. More than 4 million tonnes of agricultural products destroyed and stolen by the

occupiers were also recorded. Furthermore, the agricultural infrastructure has suffered considerable damage. Specifically, the capacity of the destroyed and damaged granaries is 8.2 million tonnes and almost 3.3 million tonnes, respectively. Experts estimate that USD 1.3 billion is needed to restore them (Tarasovskyi, 2023). The agricultural sector in Luhansk, Kherson, Donetsk, Kharkiv, and Zaporizhzhia oblasts suffered the most damage and losses.

The war, logistical problems, and the blockade of ports have had an adverse impact on foreign trade. Thus, in March 2022, exports of agricultural products and food products decreased by almost 60% and imports by 76%, respectively, compared to the same period in 2021. A sharp decline in grain exports (Fig. 2) and a lack of storage space have worsened the financial situation of agricultural producers. New security challenges have also directly or indirectly affected the global food market. The export crisis has threatened global food security.

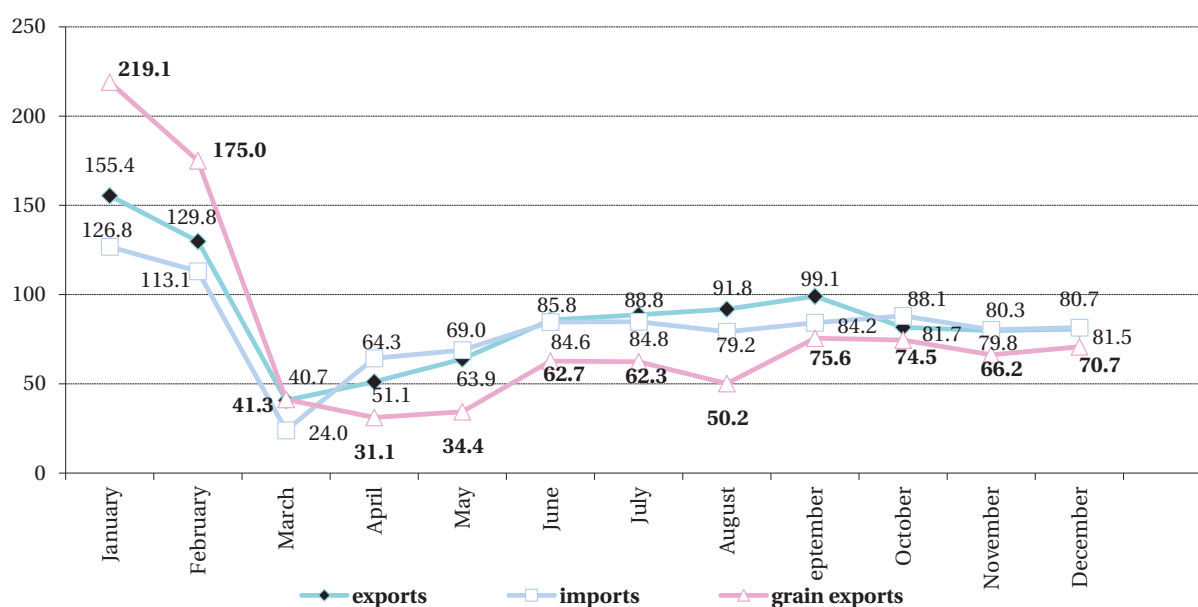


Figure 2. Indices of foreign trade in agri-food products in Ukraine in 2022 (% to the corresponding period of the previous year)

Source: compiled based on the author's calculations according to the Seasonally adjusted monthly volumes of the commodity structure of foreign trade (2021&2022)

According to the State Statistics Service, in 2019-2021, more than 90% of all capital investments in the agricultural sector of Ukraine were made at the expense of enterprises and organisations' own funds (Indexes of agricultural..., n.d.).

For many agricultural enterprises, especially small and medium-sized ones, internal resources for financing investments, such as profits and depreciation, are insufficient to ensure an effective process of extended production reproduction. The situation is catastrophic for businesses that have been completely or partially destroyed.

Due to the considerable losses and damages in Ukrainian agriculture, as well as the growing risks and dangers, a reduction in investment in agribusiness is most likely to be expected in the near future.

Given the significant deterioration in the financial condition of most agricultural enterprises due to the war, and given the new risks and dangers, investment activity in Ukrainian agriculture is becoming increasingly difficult. In the first year of the full-scale war with Russia, the volume of capital investments in agriculture, forestry and fisheries in Ukraine decreased by USD 973 million, or almost 40%, compared to the previous year. In 2022, the level of investment in the agricultural sector fell to the level of 2014. This is the largest decline in investment in agriculture in 2010-2022. Apart from 2022, a sharp decline in investment was observed in 2014 (the beginning of Russia's aggression in Ukraine) and in 2020 (the COVID-19 crisis). At that time, investment volumes decreased by USD 744 million and USD 408 million, respectively, compared to the previous 2013 and 2019 (Fig. 3).

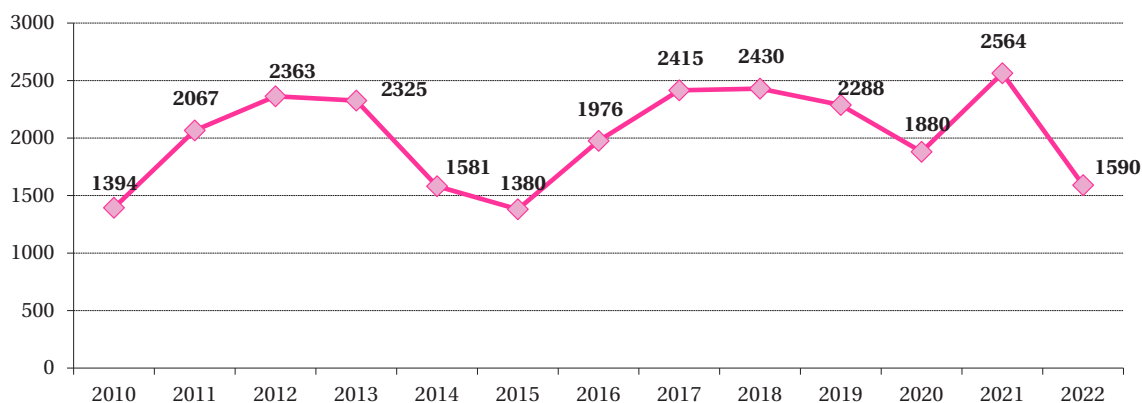


Figure 3. Dynamics of capital investment in agriculture, forestry, and fisheries in 2010-2022, USD million

Source: compiled based on M. Guliyev & T. Azizov (2022)

The specific features of agriculture often make it virtually impossible to re-profile and relocate agricultural enterprises to remote regions away from the front line during martial law. Furthermore, numerous agricultural enterprises have suffered serious damage and destruction as a result of environmental violations caused by Russia. In addition, many farmers and rural residents have left the occupied territories and the regions where hostilities are taking place. Therefore, humanitarian, and financial aid is needed to resume operations. However, farmers who apply for financial aid from the state face excessive red tape, but as a result, support is often insignificant (Mamonova, 2022).

The impact of the war on the environment will be long-term due to the need to dispose of toxic waste that is dangerous to people and the environment. L. Deyneko (2022) warns about the threat to Ukraine's anthropogenic and environmental safety due to significant water pollution and, as a result, deterioration of drinking water quality. The explosion of the Kakhovka hydroelectric power station, which resulted in massive destruction of flora and fauna, human habitats, and ecosystems, is a global environmental disaster. This will not only radically change agriculture in southern Ukraine and other regions of the country. The countries of the Black Sea basin are also at risk. The Parliamentary Assembly of the Council of Europe (PACE) has already recognised the explosion of the Kakhovka hydroelectric power station as Russia's ecocide in Ukraine. Due to the dam's explosion, 94% of irrigation systems in Kherson, 74% in Zaporizhzhia and 30% in Dnipro oblasts were left without water (Economic consequences of..., 2023). Experts estimate that irrigation will not be possible in Kherson Oblast for 2-3 years.

The fishing industry also suffered significant losses. The only state-owned sturgeon farm in Ukraine has been flooded due to the explosion of the Kakhovka HPP. This endangers the reproduction of sturgeon populations, which have a special protection status, and may lead to the extinction of these relict fish species in Ukrainian waters. The consequences will be negative not only for the ecology of Ukraine, but also for other countries of the Black Sea basin (Only state sturgeon..., 2023). Furthermore, flooding threatens the Kherson Production and Experimental Fish Farm, which is located in the occupied territory. Due to the death of 95 000 tonnes of full-grown

fish alone, material losses will amount to about UAH 4 billion (Kherson plant for..., 2023).

The aggression of the Russian Federation has considerably complicated the functioning of agribusiness in Ukraine, including small, medium, and large agricultural enterprises. Specifically, the loss of logistical connections due to the hostilities has led to serious environmental disasters at numerous livestock farms and agricultural facilities. Limited access to the transportation of agricultural products across the Black Sea continues to be one of the main challenges for agribusiness. Therefore, the recovery of economic activity will require increased efforts and investments. At the same time, the war revealed other negative consequences of the agroholding model of agricultural development in Ukraine (Borodina, 2022). Large agricultural enterprises proved to be less resilient to the new challenges and dangers associated with the hostilities. Their operations have become extremely difficult due to logistical problems, blocked markets, and real threats of environmental disasters at livestock farms.

P. Bórawski *et al.* (2020) consider the biggest problems of modern agriculture to be the volatility of agricultural prices, population growth and climate change, which causes uncertainty among both farmers and consumers. The war in Ukraine has increased the challenges and uncertainty for all food market actors, making it difficult to make many decisions, such as production, financial, marketing, etc. Furthermore, uncertainty stimulates speculative behaviour in the market, causing price fluctuations and increasing market volatility.

Economists predict that a prolonged war in Ukraine could not only undermine economic growth, but also further increase inflationary pressures (Siddiqui, 2022). At the same time, large-scale losses amid uncertainty and extreme instability are making agricultural production difficult and sometimes impossible. Without adequate government support and incentives for agricultural development, investment in agribusiness will continue to decline in the near term.

In the European Union, farm investments are supported by government programmes. One of the main goals of agricultural investment support programmes is to increase farm profits (Kirchweiger *et al.*, 2015). A large share of the Common Agricultural Policy (CAP) budget takes

the form of subsidies to support and stabilise farmers' incomes (Bojnek & Fertő, 2019). In contrast to EU countries, in Ukraine, investment in agriculture is financed mainly by producers themselves. In the structure of sources of capital investment financing, agricultural enterprises' own funds account for about 90%. In times of war, this situation becomes particularly dangerous and can pose a threat to investment, economic, and food security.

T. Zinchuk *et al.* (2021) performed a theoretical and empirical analysis of incentives for agriculture and their role in achieving food security goals. They believe that the incentives for agricultural production are strong in developing countries where agriculture contributes a significant share of gross domestic product and economic development. This conclusion is quite reasonable and fair, however, in Ukraine, where agriculture is the leading export-oriented industry and the engine of the Ukrainian economy, there is little incentive for agricultural producers.

Apart from investment support, the economy needs to recover from the crisis by creating a business environment in which all business entities can not only recover but also operate effectively. At the same time, it is necessary not only to overcome new challenges, but also to take measures to prevent corruption, especially at the highest levels of the civil service and big business, and political corruption, which is part of grand corruption and involves manipulation of legislation and procedures, manipulation of elections, etc. Furthermore, reforms of the judicial and tax systems are a top priority. Another key issue for Ukraine's agricultural sector is the introduction of measures to prevent monopoly in the industry and to ensure state protection of competition in business.

In the current situation, it is not only relevant, but also vital for Ukraine's agricultural sector to receive investment support to restore and adapt to the new challenging conditions of operation and further development. Investment support for farms is a key instrument of European agricultural policy. Each year, it is provided to a considerable number of farms across Europe to stimulate technological advance on farms, increase productivity, and help farms adapt to changing market conditions (Nilsson & Wixe, 2022).

Before the war, the amount of state support for agriculture was scarce, and most of it went to agricultural holdings and large agricultural companies. O. Borodina (2022) addresses the fact that agricultural holdings, despite their high profitability, systematically lobby for their interests, monopolising state support for the entire agricultural sector. Before the full-scale war, 5-10% of the largest agricultural enterprises accumulated 70-80% of the funds allocated by the state to support agriculture. At the same time, large agricultural enterprises received significant funds from the World Bank, the International Monetary Fund, and the European Bank for Reconstruction and Development.

Material losses and reduced incomes of agricultural producers due to the war with Russia make it difficult and sometimes impossible to operate without additional funding. Programmes to support the agricultural sector should become part of the state's anti-crisis measures. Investment support for agribusinesses should be a key element of programmes to support agriculture during the

war and post-war recovery. However, in general, the funds allocated by the state budget are very limited and disproportionate to the damage caused by the war and its consequences. Still, Ukraine receives considerable amounts of international financial aid. Therefore, the criteria for selecting business entities to support and areas of investment are important.

The structure of Ukrainian agriculture is currently somewhat deformed. On the one hand, there is the individual sector, whose activities are aimed at producing conventional goods for the domestic market, and on the other hand, the corporate sector, which includes agricultural holdings and large agricultural enterprises with a significant share of foreign capital, focused on the constant expansion of mono-commodity production and exports (Borodina, 2022). Therefore, given the current situation, it is advisable to support small and medium-sized agricultural producers. This approach is based on the vital role of these forms of business in the development of rural areas. Small and medium-sized agricultural enterprises form the budget of rural communities. Furthermore, agricultural holdings are taxed under the simplified taxation system, which means they are virtually exempt from corporate income tax. Large companies often do not have the same place of registration and place of business. Often, agricultural holdings are registered abroad, specifically in offshore zones, which has a negative impact not only on local budgets but also on the budget of Ukraine.

New challenges and threats caused by the war have intensified the destructive processes in the agricultural sector of Ukraine's economy. Specialisation in the production of raw agricultural products for further export does not contribute to the efficiency and competitiveness of the agricultural economy and the sustainable development of rural areas. A. Razumova *et al.* (2022) emphasise that the main areas of investment activity are the production of simple goods and the processing of raw materials. They consider this result to be negative. Therefore, the priority area of investment support should be the development of agricultural processing. V. Rusan (2022) believes that the priority areas of investment in the agricultural sector of Ukraine's economy should be aimed at meeting the needs of the domestic market with vital social food products, developing livestock and advanced processing, and reorienting the structure of exports to highly profitable and less tonnage raw materials and processed products with a higher added value.

At the same time, in the context of global climate change, which is intensifying and accelerating due to the war with Russia, it is crucial to ensure sustainable agricultural development. S. Berezyuk *et al.* (2023) believe that the general direction of agricultural production development should be directed towards the introduction of technology-friendly technologies. The Law of Ukraine No. 2710-IX "On the State Budget of Ukraine for 2023" (2022), with financial aid from the World Bank, provides UAH 1.56 billion for agricultural sector development programmes. Specifically, UAH 1 billion is allocated for grants for the development of gardens and greenhouses, UAH 360 million is allocated to strengthen the Partial Loan Guarantee Fund (PLGF), and UAH 201 million is allocated to support water user organisations (WUOs).

The low-interest loan programme for the sowing and harvesting season-2023, jointly with the World Bank, provides for USD 432 million (Support for agriculture..., 2023). Part of the funds from the World Bank (USD 202 million) will be used to pay interest rate compensation for loans to small and medium-sized agricultural producers and food producers under the "5-7-9%" programme. Under the government's "5-7-9%" programme, short-term working capital loans for agricultural enterprises are provided by banks under the government's guarantee at a reduced interest rate. USD 80 million will be allocated for one-time payments to agricultural producers who cultivate 1 to 120 hectares and for one-time subsidies to owners of 3-100 cattle. USD 50 million has been earmarked to support energy supply to elevators and granaries, and USD 100 million to purchase and supply wheat and corn to Africa and Asia. In 2023, Ukraine's agricultural producers also have access to a program for preferential financing, which is financed by the International Finance Corporation (IFC) (50%) and other donors (50%) to the extent of 1 million USD (Support for agriculture..., 2023).

Investment support for agribusinesses through concessional lending programmes is crucial for agricultural producers. Restoration of economic activity and functioning in a war environment, and hence increased risks and dangers, requires considerable investments. First and foremost, this concerns small and medium-sized agricultural enterprises as more financially vulnerable economic entities. L. Vdovenko (2022) addresses the low activity of attracting credit resources by agricultural enterprises and emphasises the need for financial support for small-scale producers, which, unlike large-scale enterprises, have demonstrated flexibility and capability of meeting the food needs of consumers in the domestic market under martial law.

Financial aid to Ukraine's agri-food sector will help restore production facilities and infrastructure, thereby increasing the resilience of agricultural enterprises. Furthermore, international financial aid is aimed at mitigating the impact of military challenges on world food markets and global food security. Strengthening international cooperation and investment cooperation in agriculture will facilitate the exchange of resources, knowledge, and best practices, while also supporting the sustainability of global agricultural markets and the security of the global food system.

► Conclusions

The full-scale war with the Russian Federation has resulted in significant losses in Ukraine's agriculture. New challenges are emerging, risks are increasing, and threats are appearing that pose problems for the agricultural sector and adversely affect the investment activities of agricultural enterprises. The threat to Ukraine's national security due to the military actions and occupation has had an adverse impact on the country's investment climate and the operating conditions of agricultural enterprises.

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Problems with product sales due to export blockades and disruption of logistics, a shrinking domestic market, and a decline in the purchasing power of the population increased economic risks. The war against the Russian Federation has caused considerable losses and damage to agricultural enterprises, as well as a reduction in production and income of agricultural producers.

Agricultural production in 2022 decreased by 25% compared to the previous year. A significant decline in agricultural output occurred in all regions of Ukraine, except for Lviv and Zakarpattia oblasts. Among the regions most affected by the war with the Russian Federation are Kherson, Zaporizhzhia, Donetsk, Luhansk, Kharkiv, Mykolaiv, and Odesa oblasts. In these regions, the decline in agricultural production has reached critical levels, ranging from 32% in Odesa Oblast to 95% in Kherson Oblast.

The consequences of the full-scale war led to a significant decline in investment activity in Ukrainian agriculture. In 2022, the volume of capital investments in the agricultural sector of Ukraine's economy was about 60% of the pre-war 2021 figure. This was the largest investment decline in Ukrainian agriculture in 2010-2022. The volume of investments in the agricultural sector reached the level of 2014, when Russia's aggression in Ukraine began. The war with Russia has caused serious environmental problems for Ukrainian agriculture. Environmental pollution and the consequences of the Kakhovka HPP explosion will have a long-term impact on the development of agriculture and rural areas. Restoring the environment and overcoming other adverse consequences of the war will require considerable effort and funding.

Ukraine's full-scale war with Russia has exacerbated the impact of destructive processes in the development of the agricultural economy. The raw material export-oriented model of development of the agricultural sector of Ukraine, in which the key players are large agricultural companies and agricultural holdings, has proved to be insufficiently sustainable and socially oriented and needs to be transformed. Restoring and developing Ukraine's agriculture will require significant amounts of public funding. At the same time, current challenges can open new opportunities for agribusiness development. Specifically, the recovery of the agrarian economy should be directed towards supporting small-scale, small and medium-sized agribusinesses and promoting the development of agricultural processing. Given the duration of the war and possible changes in the situation in Ukraine's agricultural sector, it is promising to repeat the survey to assess the impact of the war on investment activity more accurately.

► Acknowledgements

None.

► Conflict of Interest

The author of this study declares no conflict of interest.

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Інвестиційна діяльність у сільському господарстві України під час війни: нові виклики та загрози

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► **Анотація.** Інвестиційна діяльність є важливою умовою ефективного функціонування та розвитку аграрної економіки. Інвестиції дають змогу підприємцям досягти бажаних результатів діяльності та реалізувати стратегічні цілі підприємств. З початком вторгнення росії в Україну перед сільськогосподарськими виробниками постали нові виклики і загрози, у зв'язку з чим виникла потреба адаптуватися до нових умов. Метою статті було дослідити вплив війни на сільське господарство України та виявити нові ризики та небезпеки для інвестиційної діяльності в сільському господарстві під час війни. У процесі дослідження використано діалектичний метод наукового пізнання, аналізу й синтезу, системного узагальнення, порівняльного аналізу, а також об'єктивно-історичний, індуктивний, дедуктивний методи, евристичний метод генерації варіантів рішень та метод цільового обґрунтування. У статті розглядаються тенденції розвитку інвестиційної діяльності в аграрному секторі економіки України в довоєнний період та під час війни. Встановлено виклики та загрози для сільського господарства, спричинені агресією росії. Виявлено основні проблеми інвестиційної діяльності сільськогосподарських виробників в умовах повномасштабного вторгнення російської федерації, запропоновано шляхи подолання цих проблем та напрями підтримки сільського господарства під час війни та у післявоєнний період відновлення країни. Розглянуто деструктивні процеси в системі функціонування аграрної економіки України у довоєнний період та обґрунтовано заходи щодо їх подолання. Встановлено пріоритетні напрями інвестиційної підтримки для забезпечення сталого розвитку аграрної економіки та сільських територій. Обґрунтовано ключові орієнтири розвитку аграрного сектору економіки України. Висновки, пропозиції та практичні рекомендації можуть бути використані при розробці відповідних програм та заходів, спрямованих на підтримку сільськогосподарських виробників під час війни та у післявоєнний період відновлення національної економіки

► **Ключові слова:** продовольча безпека; ризик; небезпека; фінансова допомога



UDC 338.45:339.13:339.564

Production as a link in the market of agricultural machinery for crop farming in Ukraine

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► **Abstract.** The production of agricultural machinery and equipment in Ukraine is one of the main sources of supplying the market with resources and facilities for agricultural production, but as of 2023, it does not fully meet its needs. According to the relevance of the subject matter, the purpose of the study was to investigate the trends in the development of the agricultural engineering industry in Ukraine in dynamics, the impact of military operations on it, and to work out effective ways to overcome their negative consequences. The following methods were used: dialectical, statistical and economic, graphical, index, correlation and regression analysis, empirical, comparative analysis, analytical forecasting, abstract logical, etc. The principles of regional placement of agricultural engineering enterprises are defined, depending on the availability of raw materials, energy and labour resources. The structure of enterprises in the industry by category is determined – most of them are small enterprises (85.8-91.5%), but the majority are employed by medium-sized enterprises (59.1-79.3%). Due to military operations, the number of active enterprises in the industry has decreased by about 30 units. The trend of reducing the production of tractors, combine harvesters, and some types of tillage machines in Ukraine and the reasons for its occurrence are revealed. The prospects of production of sowing equipment in Ukraine are substantiated. The index of identified comparative advantages of different countries by individual types of machinery is analysed, and it is found that in Ukraine only tillage machinery has a high level of advantages – 1.802 and has optimistic prospects for development. The paper defines a close correlation between the export and production of tractors in Ukraine in 2010-2021 (the corresponding correlation coefficient – 0.8982). Problems that hinder the development of the agricultural machinery industry are identified: inflation, disruption of logistics links and loss of suppliers, high prices for energy resources, etc. Recommendations for overcoming them are proposed: creating favourable investment conditions; implementing protectionist customs and tax policies for industry enterprises; evacuating them from the war zone. The proposed measures will contribute to the restoration, preservation, and progressive innovative development of the potential of agricultural engineering in Ukraine

► **Keywords:** agricultural engineering; export; profit; placement of enterprises; import; tillage equipment

► **Suggested Citation:** Navrotskyi, Ya., & Petrov, V. (2023). Production as a link in the market of agricultural machinery for crop farming in Ukraine. *Ekonomika APK*, 30(5), 19-32. doi: 10.32317/2221-1055.202305019.

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► Introduction

The determining factors for the development and effective functioning of any commodity market, including the market of agricultural machinery and equipment, is the balance of supply (formed primarily by domestic production and imports) and demand (formed by consumers of the corresponding products). Ukraine's own production of agricultural machinery is not only a prerequisite for the effective development of the domestic agricultural sector, but also a factor in preserving and improving the quality of labour potential, ensuring stable budget revenues, preventing the outflow of foreign currency from the country, and stimulating its inflow through increased exports, development of logistics and social infrastructure, etc.

H. Bernhardt *et al.* (2021) focused on the interaction between Industry 4.0 and Agriculture 4.0. The researchers suggest that network interaction between producers of mechanisation tools is necessary to maximise the satisfaction of agricultural needs in innovative technology, which contributes to the use of a set of innovative products of Industry 4.0 directly for agriculture. R. Vidosa *et al.* (2022) substantiated the need for the transition of agricultural machinery to ISO 11783 (ISOBUS) standards at the global level to achieve compliance of machinery with the requirements of Agriculture 4.0 and the retention of the market segment at the local level, competing with multinational companies. Compliance with these standards will also contribute to the development of effective business models related to the maintenance of machinery and equipment.

The risk assessment for autonomous agricultural machines was investigated by J.M. Shutske *et al.* (2023). According to the researchers, the safety of agricultural machinery is a problem for stakeholders and an obstacle to the widespread introduction of automated technical means. Based on the survey of engineers-practitioners and researchers who design automated and autonomous agricultural machines, the needs beyond interference and operator injury prevention were identified: safety issues and risks associated with farm animals, property, infrastructure, downtime, and the environment. The researchers proposed ways to further develop safety standards, including the need for software and operational data for designing autonomous machines.

Z.-L. Zhao *et al.* (2022) suggest that data on warranty cases for assessing the reliability of equipment in the field by its manufacturers is the most easily accessible and valuable source of information. Identifying the relationship between product reliability and reliability factors is one of the key factors for improving product quality. The researchers used the random survival forest (RSF) method, which is adapted for machine processing and analysis, to model the reliability level. The quality of tractors was investigated by Y. Li *et al.* (2019), who substantiated the crucial importance of the supply chain in the manufacturing process, since most of the components come from external suppliers. The proposed approach allows evaluating the supplier based on the analysis of data from incoming quality control and maintenance of equipment after its sale.

B. Sui *et al.* (2019) analysed scientific and technical innovations in agricultural engineering in three aspects: industrial development, environmental revival, and human

resources revival. The researchers suggest that the key task of scientific and technical innovations in agricultural engineering is precisely the training of personnel in the future. To increase the competitiveness of Ukrainian-made equipment, G.O. Kovalenko & O.G. Kovalenko (2021) offer: to update production equipment at enterprises; to implement the transition to international standards of production of equipment; to introduce strict control over product quality; to establish cooperation with research institutions on mutually beneficial terms.

The purpose of the study by A. Hoose & M. Kripka (2021) was an assessment of the environmental impact of technologies in agricultural engineering throughout the process chain. The study analysed the production process of a product and assessed its impact on the environment based on three factors of damage caused: human health, ecosystem, and resource scarcity. A close correlation was found between the use of carbon and stainless steel, the laser processing process, and the environmental impact. In this case, the factor of harm to human health lies in an increase of the greenhouse effect. The use of natural resources for energy needs is the most influential factor in creating a shortage of minerals.

A. Malik & S. Kohli (2020) identified the advantages of the production and operation of electric agricultural machinery and the problems associated with its introduction into agricultural production. The researchers considered high torque, low operating and maintenance costs, and no harmful emissions to be the advantages. Deterrent factors were: high initial cost, lack of charging infrastructure and insufficient perception of the harmfulness of equipment emissions on conventional carbon energy carriers. One of the problems of effective development of agricultural engineering is flexibility in managing the production process, which is extremely important in a globalised economy. Based on the product-service system (PSS), C. Kolling *et al.* (2022) proposed a conceptual model for the implementation of a product-oriented life cycle management system for agricultural machinery, which allows its producers to expand their understanding of the "product-service" system and promote sustainable production of machinery, in accordance with changing consumer requirements.

In the context of Ukraine's declared desire to integrate into European and world economic institutions, to participate in the global division of labour, these problems and challenges increasingly affect the development of Ukrainian agricultural engineering. Accordingly, the purpose of the study was to analyse current trends in the development of the industry in order to work out effective measures for its restoration and further innovative development in the post-war period.

► Materials and Methods

The analysis of the state of agricultural machinery production, its export potential, and prospects for its development in the post-war period in Ukraine on a scientific basis is reflected in the corresponding methodological approach. The methodological basis of the research is the dialectical method of cognition and a systematic approach to studying the development of agricultural machinery production for crop farming in Ukraine. The following

methods of scientific cognition were used. Data analysis was used to highlight the views of researchers on the issues and problems considered in the paper. Economic and statistical – was used in the process of analysing export operations and profitability, and reflecting the dynamics of the availability of enterprises and the availability of employees. Tabular and graphical methods were used to visually display the results of the study in the form of figures and tables. The analysis and synthesis were used to investigate the state of Ukrainian agricultural engineering during the war period. The comparative analysis was used in the process of determining the main problems of development of the agricultural engineering industry. The analytical forecasting was used to determine tasks and recommendations for the development of the industry in the post-war period. The abstract logical method was used to generalise and formulate conclusions.

The statistical method was used to study the influence of factors of foreign economic activity, forecasting the situation on the agricultural machinery market in the post-war period. The characteristics of export operations change over time, and indicators of dynamics series are used to assess their intensity. To obtain absolute growth, a chain analysis method was used – comparing the number of active enterprises and their growth or decline due to the impact of war on regions. The index method was used to analyse the level of revealed comparative advantages (RCA) of agricultural engineering products in different countries. The indicator was calculated using the equation:

$$RCA = (X_{ij}/X_i)/(X_{nj}/X_n), \quad (1)$$

where X_{ij} – export of goods j from the country i ; X_i – total export of the country i ; X_{nj} – total export of goods j in the world; X_n – total exports of the world's countries. In other words, the index shows the ratio of the share of a product (industry) in national exports to the share of this product in world exports.

Correlation and regression analysis was used to determine the close relationship between export volumes and tractor production, the level of dependence of changes in the effective feature (tractor production volumes) on the influence of the factor feature (export volumes). The information base of the study was the papers by Ukrainian (Bolyanskaya & Bolyansky, 2020; Navrotskyi & Petrov, 2023) and foreign researchers (Ruffoni & Reichert, 2022). The methodological basis was also provided by reference and information publications, statistical and analytical data from the Ministry of Agrarian Policy has disclosed data on UAH 13 billion of state support over the past three years (2021) for 2020, as certain data has not yet been made public or is not available, Activities of enterprises (n.d.), BI – Foreign trade indicators of Ukraine (n.d.).

► Results and Discussion

The regional location of agricultural engineering enterprises in Ukraine has historically been based on the principles of economic feasibility. The availability of raw materials (primarily suppliers of metal components), energy and water resources, appropriate labour potential and developed agricultural production determined the location of most equipment manufacturers in the southern, eastern, and central regions of the country (Table 1).

Table 1. Location of agricultural engineering enterprises in Ukraine in 2020

Oblast	Legal entities, units	Individual entrepreneurs, units	Individual entrepreneurs, %
Zaporizhzhia	74	46	38.3
Kharkiv	40	27	40.3
Dnipropetrovsk	54	7	11.5
Kirovohrad	31	12	27.9
Kyiv city	35	4	10.3
Vinnitsia	24	11	31.4
Kyiv	21	12	36.4
Zhytomyr	20	7	25.9
Cherkasy	16	11	40.7
Khmelnitskyi	11	14	56.0
Poltava	14	11	44.0
Odesa	16	3	15.8
Lviv	12	6	33.3
Mykolaiv	13	5	27.8
Sumy	11	3	21.4
Kherson	8	5	38.5
Chernihiv	8	1	11.1
Luhansk	3	2	40.0
Ivano-Frankivsk	3	1	25.0
Ternopil	1	3	75.0
Zakarpattia	3	1	25.0

Table 1, Continued

Oblast	Legal entities, units	Individual entrepreneurs, units	Individual entrepreneurs, %
Rivne	3	0	0.0
Volyn	0	2	100.0
Chernivtsi	1	0	0.0
Donetsk	0	0	0.0
Total	616	194	31.5

Source: developed by the authors based on Activities of enterprises (n.d.)

The western region is less saturated with machine-building enterprises (for example, in the Zakarpattia and Rivne oblasts there are only three enterprises, in Volyn – two, and in Chernivtsi – only one). This is conditioned by the distance from the raw material (metallurgical) base and a significantly lower level of concentration of agricultural production (primarily crop production) compared to other regions. However, with the outbreak of hostilities, it was the eastern and southern regions with the most developed agricultural machinery that were either under occupation or became frontline territories, which practically paralysed the activities of industrial enterprises and continues to lead to their physical destruction as a result of deliberate targeting by the aggressor. A significant proportion of agricultural machinery manufacturers in

Ukraine are registered as individual entrepreneurs whose income is limited by tax legislation (Tax Code of Ukraine..., 2010). Based on the data in Table 1, most of them are in Khmelnytskyi – 14 (56%), Poltava – 11 (44%), Cherkasy – 11 (41%) and Kharkiv – 27 (40%) oblasts. In the Volyn Oblast, both registered enterprises are individual entrepreneurs, and in the Ternopil Oblast – three out of four.

The dynamics of the number and share of agricultural machinery producers in Ukraine in terms of production concentration indicates the dominance of the category of microenterprises (Table 2). Their share in 2010 was 81.4% of all agricultural engineering enterprises, but by 2020-2021 it decreased, respectively, to 61.3 and 68.5%. In general, the share of small businesses in the industry in 2021 was 91.5%.

Table 2. Number and share of agricultural engineering enterprises by individual categories in Ukraine

Years	Large enterprises		Medium-sized enterprises		Small enterprises		of these, microenterprises		Total, units
	units	%	units	%	units	%	units	%	
2010	3	0.4	61	8.2	683	91.4	608	81.4	747
2011	2	0.3	70	10.3	608	89.4	507	74.6	680
2012	3	0.7	60	13.5	381	85.8	272	61.3	444
2013	2	0.4	50	11.1	398	88.5	278	61.8	450
2014	2	0.4	47	9.8	430	89.8	318	66.4	479
2015	2	0.4	48	9.6	450	90.0	348	69.6	500
2016	1	0.2	55	10.4	473	89.4	370	69.9	529
2017	0	0.0	66	12.1	479	87.9	363	66.6	545
2018	0	0.0	66	11.8	495	88.2	378	67.4	561
2019	0	0.0	64	10.8	527	89.2	399	67.5	591
2020	0	0.0	56	9.1	560	90.9	427	69.3	616
2021	1	0.2	52	8.3	573	91.5	429	68.5	626

Source: developed by the authors based on Activities of enterprises (n.d.)

Due to the low level of concentration of resource potential (production, technological, financial, investment, intellectual, labour) small enterprises are unable to ensure the production of modern complex innovative means of mechanisation of agricultural production. Their activities are aimed at manufacturing, as a rule, small batches of non-complex machines and tools, spare parts or components for complex equipment, and introducing large-unit assembly of individual modifications of machines or technological complexes (Datsenko, 2019).

In 2021-2022, there were significant changes in the territorial distribution of agricultural machinery

producers in Ukraine. Naturally, in the southern and eastern regions, which were most affected by military operations, the number of machine-building enterprises decreased. In Zaporizhzhia, Kharkiv, and Mykolaiv oblasts, this decrease was 11, 7 and 4 units, respectively. Some enterprises were relocated to the western and central regions (Volyn, Zakarpattia, Ivano-Frankivsk, Kyiv, Odesa, Ternopil, Chernivtsi oblasts), some simply stopped operating due to various circumstances.

In general, during the year of military operations, the number of active enterprises in the industry decreased by 30 units (Fig. 1).

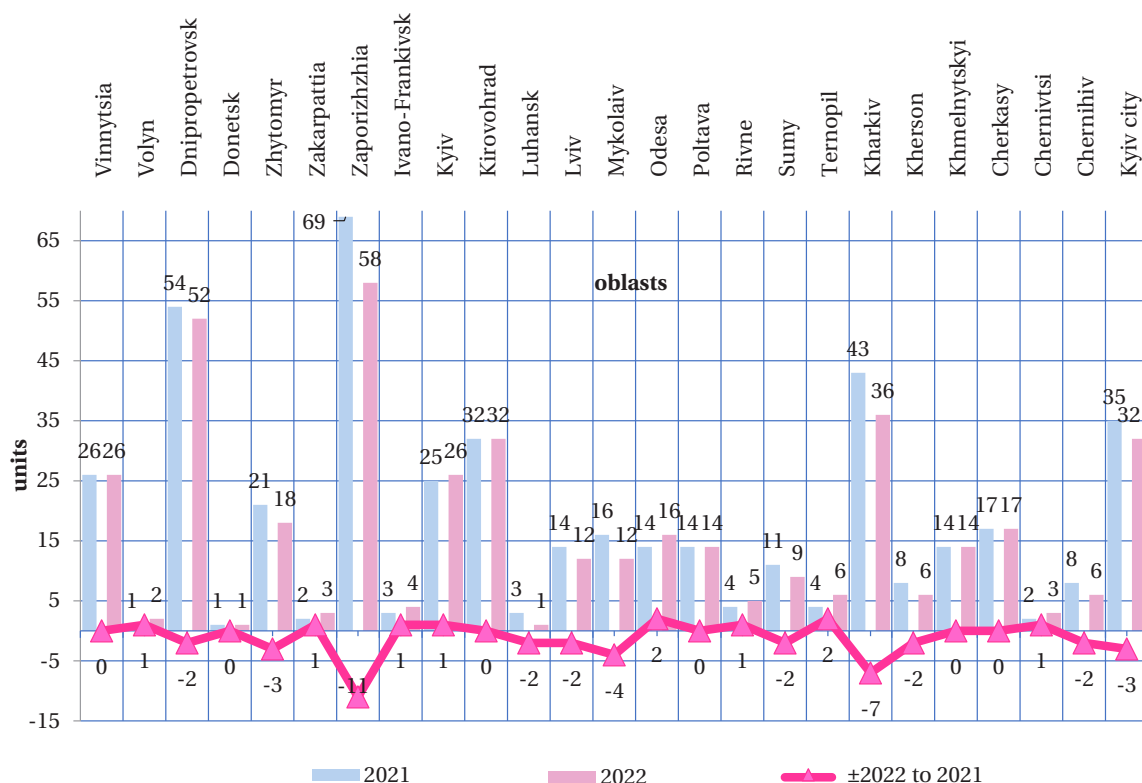


Figure 1. Number of active agricultural engineering enterprises by regions of Ukraine in 2021-2022 as of November 1, units

Source: developed by the authors based on the Register of statistical units (n.d.)

According to the level of concentration of labour potential among agricultural machinery manufacturers in

Ukraine, the leading positions are traditionally occupied by large and medium-sized enterprises (Table 3).

Table 3. Number of employees at agricultural engineering enterprises in Ukraine

Years	Total, persons	Business categories							
		large		medium		small		of these, microenterprises	
		persons	%	persons	%	persons	%	persons	%
2010*	24 893	6472	26.0	14 705	59.1	3716	14.9	1460	5.9
2011	–	c	c	15 308	62.8	c	c	1385	5.7
2012	23 542	4523	19.2	15 260	64.8	3759	16	802	3.4
2013	–	c	c	c	c	3752	19.4	728	3.8
2014	–	c	c	c	c	3700	20.2	852	4.7
2015	–	c	c	c	c	3245	16.5	913	4.6
2016*	19 084	592	3.1	15 128	79.3	3364	17.6	923	4.8
2017	–	0	0	c	c	c	c	969	4.7
2018	–	0	0	c	c	c	c	1122	5.4
2019	–	0	0	c	c	c	c	1031	5.8
2020	16 615	0	0	12 250	73.7	4365	26.3	1067	6.4
2021	–	c	c	c	c	4843	28.9	1147	6.8

Note: c – data are not disclosed to ensure compliance with the requirements of the Law of Ukraine No. 2614-XII “On State Statistics” (1992) regarding the confidentiality of statistical information; * – estimated total employment and employment at large enterprises

Source: developed by the authors based on Activities of enterprises (n.d.)

As of 2023, it is difficult to conduct a thorough analysis of the relevant data due to the limited amount of statistical information in the public domain. But the published data indicate that the share of employees at large and medium-sized enterprises in 2010-2021 was at the level of 71-85%. The number of employees in the industry in the study period decreased by 8278 people (33.3%). The tendency to reduce employees at agricultural engineering enterprises

and the growth of their share in small companies indicates an overall decrease in production volumes at them (in particular, high-tech and innovative products), loss of competitive positions of Ukrainian machine-building products on the market, and simplification of the technological process. The analysis of indicators of economic efficiency of agricultural engineering enterprises in Ukraine for 2010-2021 suggests the instability of the industry's development (Fig. 2).

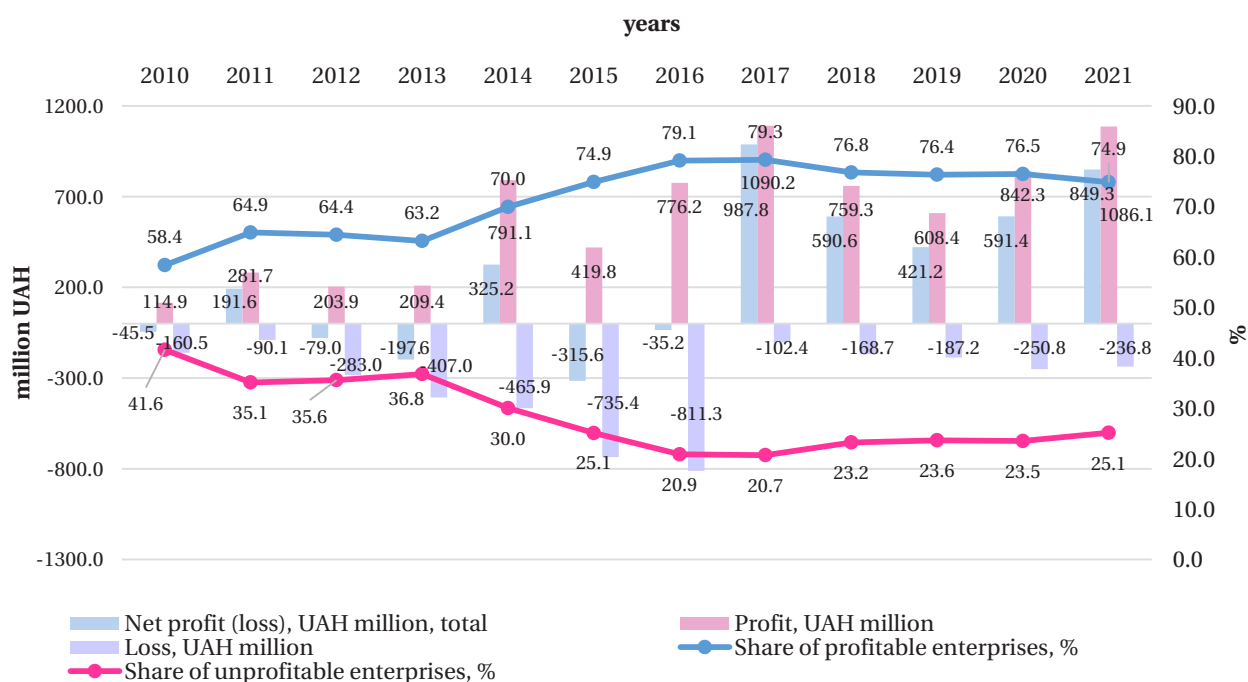


Figure 2. Dynamics of profitability (unprofitability) of agricultural engineering enterprises in 2010-2021

Source: developed by the authors based on Activities of enterprises (n.d.)

Over the 12 years of observation, five agricultural machinery companies have made a loss in total. One of the factors of growth in the profitability of the industry in 2017-2021 was the implementation in Ukraine from 2017 of the national programme of partial compensation for the cost of agricultural machinery and equipment of domestic production, which stimulated the growth of production of machine-building products and their sale to rural producers (Resolution of the..., 2017). The programme became a small example of a more or less effective mechanism of state support for agriculture and industrial engineering during the time of independence (Farmers are asking..., 2022) and allowed Ukrainian agricultural machinery to slightly improve its position in the domestic market.

The independent Ukraine inherited from the former USSR a powerful machine-building complex for the production of agricultural machinery and equipment: in 1991, the Ukrainian industry produced 90.2 thousand tractors, 71.9 thousand ploughs, and 48.7 thousand seed drills (Samchenko, 1992). The general economic crisis caused by the collapse of the then unified national economic complex, the loss of inter-republican economic ties, outdated production technologies and, accordingly, the low competitiveness of Ukrainian equipment in foreign markets, the import of foreign high-quality machinery and equipment led to the decline and loss of powerful production

potential, which until recently allowed the development and production in Ukraine of fully equipped technological complexes for crop and livestock production. The level of localisation of Ukrainian complex agricultural machinery is quite low – machinery and equipment are equipped with foreign-made components and assemblies.

In Ukraine, there is historically no culture of production of self-propelled combine harvesters, so state funding for development work on their design and establishment of mass production has not led to positive results. Attempts to establish the production of licensed machines or create joint ventures with leading Western manufacturers of relevant machine-building products are not successful, primarily due to unbalanced state policies and weak control over the use of budget funds. As a result, the Ukrainian market is saturated with imported combines. New machines of the world's best brands and used combine harvesters in the secondary market actively compete with each other in the market. Only a small number of harvesting machines assembled in Ukraine from foreign components were in demand due to the state programme of partial compensation for the cost of machinery and equipment of domestic production. During 2010-2021, in 2011 alone, the output of combine harvesters amounted to 399 units, but this is only 15.2% of the 2619 units imported in that year (Fig. 3).

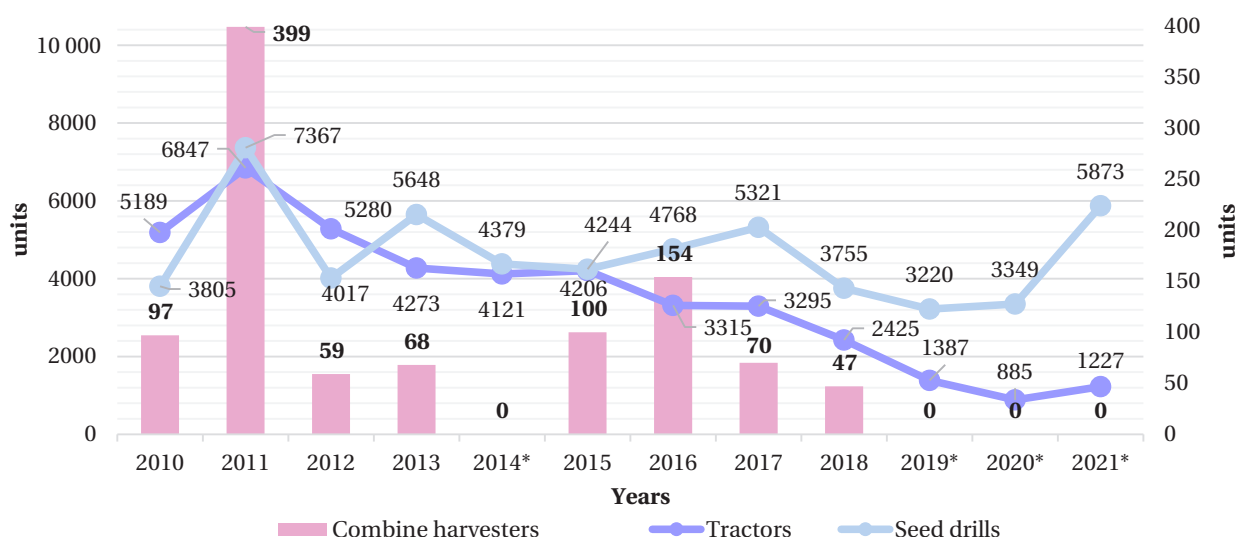


Figure 3. Production of certain types of agricultural machinery in Ukraine, units

Note: * – the data is confidential in accordance with the Law of Ukraine No. 2614-XII “On State Statistics” (1992)

Source: developed by the authors on based on data Activities of enterprises (n.d.)

During 2011-2021, tractor production in Ukraine decreased by 5-8 times. The gradual reduction of the market for power vehicles in the Russian Federation and its complete loss since 2019, together with their low competitiveness in comparison with foreign analogues, significantly limited the export opportunities of the Ukrainian tractor machinery industry. The production of various types of seed drills remains relatively stable in Ukraine (in 2010-2021, respectively, 3.2-5.9 thousand units), which is

identified primarily with the flagship of domestic agricultural engineering.

The segment of the tillage equipment market is promising from the standpoint of meeting the needs of Ukrainian production. The vast majority of types of tillage machines and tools are not complex, their production does not require large capacity, advanced technologies and qualified engineering and technical personnel (Fig. 4).

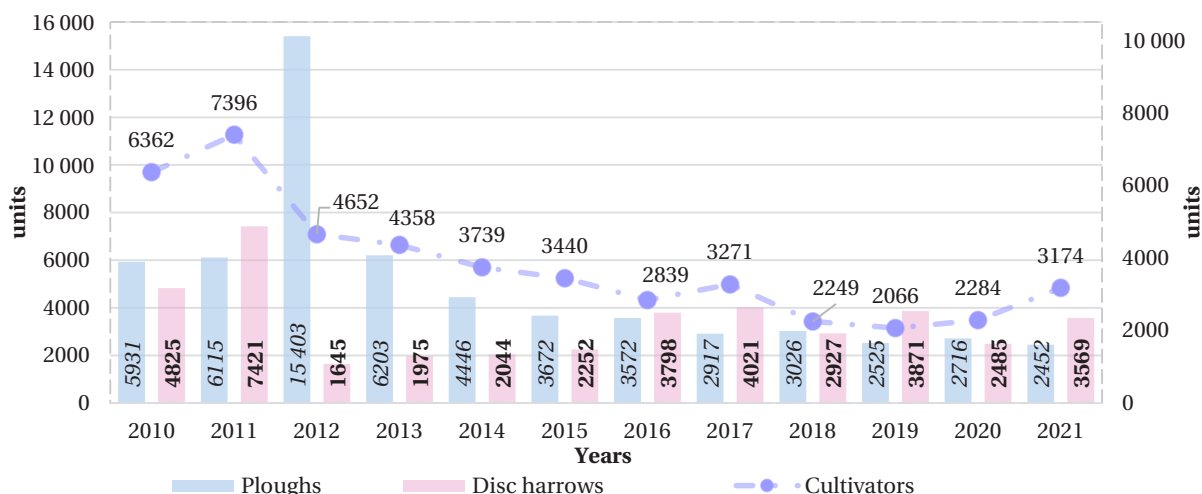


Figure 4. Dynamics of production of tillage machines and tools in Ukraine, units

Source: developed by the authors based on data from Activities of enterprises (n.d.)

During 2010-2021, the production of ploughs, disc harrows, and cultivators of various types in Ukraine has relatively stabilised, which gives grounds to assert that the market is sufficiently saturated with them and, accordingly, meets the demand of rural producers. The shift in the market segment of tillage machines and tools is significantly affected by the intensive introduction of modern alternative technologies of soil-free tillage in agricultural enterprises (Prymak *et al.*, 2018). Consequently, the demand for

shelf ploughs is decreasing, while the demand for disc, flat-cutting, chisel, and other types of tools that work without rotating the chaff is growing. The high export potential of agricultural engineering in any country indicates the use of modern innovative technologies in production and high competitiveness of products. To assess the export potential, the RCA index is used, which is internationally used to calculate the relative advantages or disadvantages of a country in a particular market segment (Table 4).

Table 4. Index of revealed comparative advantages of certain types of agricultural machinery in 2021

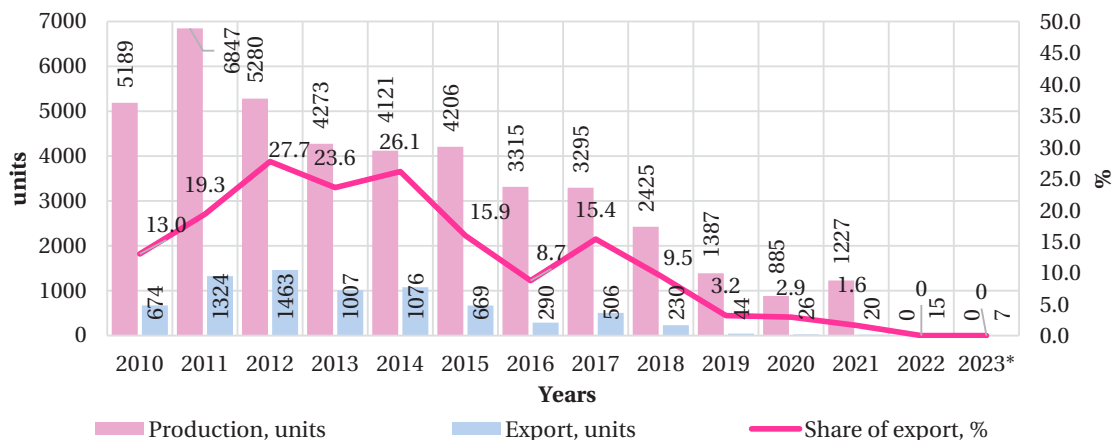
Country	Equipment type		
	tillage equipment	harvesting equipment	tractors
Ukraine	1.802	0.273	0.034
Belarus	3.957	4.601	5.900
Kazakhstan	0.058	0.024	0.020
Moldova	0.467	0.278	0.020
Poland	1.967	2.693	1.411
Czech Republic	2.772	1.957	0.379
France	1.967	1.886	2.561
Italy	3.451	2.251	1.253
Germany	2.500	2.439	2.182
USA	0.856	1.694	1.008
Argentina	0.476	0.411	0.005
Brazil	1.319	1.116	1.744
India	1.093	0.217	1.182
China	0.692	0.867	0.260

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

The index value from 0 to 1 indicates a low level of competitive advantages of products in international markets. In 2021, Ukraine had a fairly high level of competitive advantages only in terms of tillage equipment (including sowing equipment) – 1.802; the lowest indicator for tractors – only 0.034. The CIS countries – Moldova and Kazakhstan – also have low indicators. Belarus has quite high indicators of the RCA index. It was able to maintain its production and export potential due to the simplicity of its agricultural machinery. Italy (3.451), the Czech Republic (2.772), and Germany (2.500) are the leaders in tillage equipment; Poland (2.693), Italy (2.251), and Germany (2.439) are the best performers in harvesting machines; and France (2.561), Germany (2.182), and Brazil (1.744) have the highest competitive advantage in tractors. The relatively low index of competitive advantages of US products is explained by the location of industrial capacities of agricultural machinery manufacturers in Germany, Poland, Italy, France, etc., which contributes to the growth of the RCA index in these countries. The

low (significantly less than 1.0) level of competitive advantages of Chinese-made equipment is explained by its relatively low consumer characteristics and the focus of mostly rural producers with a low level of concentration of agricultural production. However, in the period from 2013 to 2023, the country has seen a steady trend towards improving the quality and expanding the range of machines, including those for use on large areas.

The correlation analysis of the relationship between tractor production and export in 2010-2021 clearly indicates that it is quite high ($r=0.8982$) and approaches very high on the Cheddock scale (Kushnir & Zavalnyuk, 2018). Value of the coefficient of determination ($R^2=0.8069$) indicates a high dependence of changes in the effective attribute, which is production volumes, on the influence of the factorial attribute (in this case, export volumes) (Fig. 5). These data clearly show that in Ukraine, with a decrease in export volumes (demand on foreign markets), tractor production volumes adequately decrease.

**Figure 5.** Production and export of tractors in Ukraine

Note: 2022-2023 – there are no statistics on tractor production; * – for January-July 2023

Source: developed by the authors based on data from Activities of enterprises (n.d.); BI – Foreign trade... (n.d.)

The main importer of Ukrainian tractors before the relevant ban in 2019 was the Russian Federation. During 2010-2018, the share of exports of Ukrainian tractors to this country was 75.0-97.2% (maximum in 2017 – 492 units). That is, export flows of this type of agricultural machinery were mainly directed to one regional market, while deliveries to the markets of other countries occurred in very limited volumes. In general, over the

past ten years, Ukraine has supplied tractors of its own production to Armenia, Georgia, Kazakhstan, Congo, Cuba, Moldova, Poland, and Romania (Activities of enterprises, n.d.; BI – Foreign trade..., n.d.). The export of Ukrainian-made sowing equipment is more diversified than the export of tractors. However, the main importer of Ukrainian sowing machines until 2019 was also the Russian Federation (Table 5).

Table 5. Exports of seed drills, planters, and seedling planting machines from Ukraine

Years	Countries													
	Russia		Kazakhstan		Moldova		Belarus		Poland		Romania		USA	
	units	%	units	%	units	%	units	%	units	%	units	%	units	%
2010	1403	80.2	135	7.7	85	4.9	–	–	–	–	–	–	–	–
2011	2985	84.5	170	4.8	165	4.7	–	–	–	–	–	–	–	–
2012	1381	71.4	144	7.4	121	6.3	–	–	–	–	–	–	–	–
2013	1652	67.1	220	8.9	–	–	322	13.1	–	–	–	–	–	–
2014	1503	46.8	–	–	641	20.0	679	21.1	–	–	–	–	–	–
2015	1706	37.1	–	–	1707	37.1	582	12.7	–	–	–	–	–	–
2016	1933	28.2	–	–	3259	47.5	1207	17.6	–	–	–	–	–	–
2017	2463	27.2	–	–	4354	48.2	1897	21.0	–	–	–	–	–	–
2018	2646	34.0	–	–	4451	57.2	434	5.6	–	–	–	–	–	–
2019	–	–	–	–	4549	52.3	1744	20.1	–	–	1999	23.0	–	–
2020	–	–	186	6.3	168	5.7	2221	75.7	–	–	–	–	–	–
2021	–	–	–	–	1276	28.5	1665	37.1	–	–	–	–	540	12.0
2022	–	–	–	–	1282	25.5	–	–	604	12.0	–	–	2220	44.2
2023	–	–	141	8.3	1079	63.4	–	–	140	8.2	–	–	–	–

Note: 2023 – January-July

Source: developed by the authors based on data from Activities of enterprises (n.d.); BI – Foreign trade... (n.d.)

The positive trend in exports of Ukrainian sowing machines to the US is noteworthy. In 2021-2022, 540 and 2220 seed drills of various designs were delivered to this country, respectively, which accounted for 12.0 and 44.2% of the total volume of their deliveries to foreign markets. The development of such a complex balanced market by Ukrainian industrial machine-building enterprises gives every reason to state the high level of competitiveness of their products and favourable opportunities for expanding the geography of export supplies, primarily to the countries of Eastern and Western Europe, the Baltic states, etc. As of 2023, the development of industrial enterprises of agricultural engineering in Ukraine is extremely negatively affected by large-scale military operations. A significant part of the production capacity of the industry's enterprises has been destroyed, damaged, under occupation or located in a war zone. Economic factors of negative impact on their production activities also traditionally remain inflationary processes, disruption of logistics links and cooperation with suppliers, rising prices for energy resources, problems with qualified personnel, etc.

Kharkiv Tractor Plant, a leading domestic manufacturer of tractors, already suffered significant destruction at the beginning of the war and lost 75% of its value – from USD 40 million to USD 10 million (The value of Yaroslavsky's..., 2022). Berdyansk "John Greaves" plant,

specialising in the production of harvesters for various crops, was occupied, and today its production facilities are being re-profiled to meet the needs of the enemy army (Who got the..., 2023). The city-forming plant "Orikhivsil-mash", which was located in the war zone and received significant damage, was relocated to Zaporizhzhia in time and partially resumed its work (Zaporizhzhia company..., 2022). A significant reduction in the production of Ukrainian machinery will lead to a decrease in its presence on the domestic market, loss of export potential and restriction of access to cheap domestic machinery by rural producers.

Given the negative impact of the war, the further development of Ukrainian agricultural engineering will face complex systemic problems, which will be impossible to overcome without active state assistance. As a result of the physical destruction and damage, a number of high-tech enterprises are expected to be irretrievably lost, and their restoration will require large investments, both private and public. Due to forced migration and departure to the Armed Forces of Ukraine, as of 2023, there is an acute shortage of highly qualified engineers and workers in the industry, and this problem continues to deepen. Restoring broken logistics chains and supplier relationships will also require large organisational, managerial, financial, and other costs. Permanent growth in the cost of energy carriers will reduce the price competitiveness of domestic

agricultural machinery and tools in industry markets (NEURC revises electricity..., 2023).

Presented on 3 July 2023 by the Ministry of Agrarian Policy and Food, the presentation “Strategy for the development of the agro-industrial complex” envisages the construction of 2 motor machinery plants with a capacity of 1200 tractors and 300 combines, as well as 6 plants of mounted and trailed machinery with a capacity of 10 000 units per year, with investments of USD 720 million. Due to the new production, it is planned to replace imports by USD 1.2 billion and ensure the growth of export potential by USD 0.9 billion (Strategy for..., 2023). Given the capacity of the Ukrainian agricultural machinery market and projected export volumes, the planned measures are clearly insufficient. After all, in 2021 alone, Ukraine imported 30 318 tractors with a customs value of USD 574.3 million, 3029 combine harvesters (USD 283.8 million) and 85 022 units of the main types of mounted and trailed equipment for crop production (USD 323.6 million). In 2022, when part of the territories was already lost, 16 689 tractors (USD 314.4 million), 2104 combine harvesters (USD 177.4 million) and 53 227 units of other equipment (USD 156.9 million) were imported. Even during January-July 2023, Ukraine has already imported 7732 tractors (USD 164.8 million), 1329 combine harvesters (USD 100.8 million) and 21 551 units of other equipment (USD 106.6 million) (BI – Foreign trade..., n.d.). That is, the annual additional production of 1200 tractors compensates only 7.1%, 300 combine harvesters – 14.6%, 10 000 units of mounted and trailed equipment – 18.8% of imports in 2022. Therefore, it should be considered advisable to direct investments to the restoration, modernisation, and creation of joint ventures with the world's leading manufacturers of agricultural machinery based on the existing production capacity of the industry. In addition, it is worth resuming the programme of partial compensation for the cost of agricultural machinery and equipment of domestic production, which was suspended due to the outbreak of hostilities in 2022. After all, due to this programme, in 2017, 1220 enterprises purchased 2906 units of equipment for a total of UAH 670.28 million; in 2018, 7043 enterprises purchased 17 182 units of agricultural machinery and equipment for the amount of UAH 3 651.76 million; in 2019, 9508 farms took part in the programme, a total of 25 075 units of equipment with a total cost of UAH 5 786.2 million; in 2020, 7260 enterprises purchased 14 946 units of equipment worth UAH 4 331.92 million; 2021 was also successful for both manufacturers of equipment and its consumers – 5789 agricultural enterprises purchased almost 30 thousand machines (Ministry of Agrarian..., 2021).

To overcome the negative consequences of the impact of the war on the development of the agricultural machinery industry, the state must create favourable investment conditions and implement a number of measures. The implementation of a balanced protectionist customs policy will allow, on the one hand, to protect the domestic producer of agricultural machinery, and on the other – to ensure the unhindered import of machinery and equipment that belongs to the category of critical imports, for example, combine harvesters. Creating a favourable investment climate and simplifying business conditions should be carried out not only during the war, but also after its end.

This will provide prerequisites for attracting external and internal investment in the restoration, reconstruction, and development of new enterprises for the production of equipment for rural areas, including through the organisation of joint ventures with the world's leading manufacturers. Providing tax holidays and tax benefits for industry enterprises not only for the duration of recovery, but also for the time of reaching the project capacity will give an impetus to their active development and attract additional sources of investment. The relocation of industrial enterprises from the war zone to safe regions will allow preserving not only production, but also personnel potential. A striking example of this approach is the evacuation of the “Orikhivsilmarsh” enterprise to Zaporizhzhia and the resumption of its operation in a short time (Navrotskyi & Petrov, 2023; Yevtushenko *et al.*, 2022).

The negative factors caused by the war for the development of the agricultural machinery industry include inflation, disruption of logistics chains, loss of ties with suppliers, high prices for energy resources, and personnel problems. The destruction and occupation of a significant part of the industry's enterprises also have a negative impact on the effectiveness of their development. To overcome the negative consequences of the impact of military operations on the further development of agricultural machinery in Ukraine, it is necessary to implement the following measures: restore the state programme of partial compensation for the cost of agricultural machinery and equipment of domestic production; implement a protectionist customs policy at the state level; create a favourable investment climate and simplify business conditions; introduce a preferential taxation regime for enterprises of the industry during their recovery and reaching their design capacity; evacuate enterprises from the war zone to safe regions; constantly carry out measures to preserve the personnel potential of the industry. The proposed measures will contribute to the restoration of the agricultural machine-building complex of Ukraine, the introduction of innovative production technologies, and improving its quality to the level of the best world samples, which will increase the export potential of the industry and develop new markets for domestic agricultural machinery.

The statement of V.V. Nekhai & O.V. Kravets (2022) regarding the need to build several single-sector technologically related enterprises on the basis of agricultural machinery enterprises of Ukraine to jointly create a customer value chain, promote and sell goods and services, manage customer relations through a single, separate coordination centre that implements an integrated strategic marketing and sales policy on behalf of and at the expense of all participating companies is considered debatable. In fact, the authors propose the creation of cartels. Although there is no such term in Ukrainian legislation, there is a similar one – “anticompetitive concerted actions”, which are actions that have led or may lead to the prevention, elimination or restriction of competition. The commission of anticompetitive concerted actions is prohibited and entails liability under the Law of Ukraine No. 2614-XII “On State Statistics” (1992). In order to increase the competitiveness of industry products, increase their sales volumes, increase export potential and expand sales markets, it is necessary to introduce international standards of quality,

safety, and environmental friendliness at enterprises. The transition to international production standards allows equipment manufacturers, including Ukrainian ones, to maintain and expand their presence in the domestic market and develop new foreign markets (Vidoso *et al.*, 2022). For example, harmonisation of standards for the production and trade of tractors contributes to the growth of sales volumes between countries, as it reduces duplication of tests in foreign markets, reduces transaction costs in the process of resolving trade disputes, improves the risk management of producers and positively affects the growth of demand of agricultural producers through trust in internationally certified products.

One of the priority tasks of the agricultural machine-building complex is customer orientation, which implies high reliability, safety, environmental friendliness, ergonomics, and cost-effectiveness of products. F. Grandi *et al.* (2018) use the term “perceived quality”, which implies human orientation through the aesthetic design of equipment, optimal performance characteristics, high reliability, ease of use, availability, cost, etc. M. Fagnoli & M. Lombardi (2020) substantiated the need for the most human-centred approach to addressing tractor safety issues. One of the factors contributing to the problem is the lack of a unified, reliable system of technical standards. The researchers investigated the need to upgrade the ROPS system (rollover protection system) on older tractors. P. Gupta & A. Mittal (2021) analysed the activities of a tractor manufacturer that lost its position in the market, but due to total quality management (TQM) optimisation, it was able to restore them. Increasing the level of customer satisfaction has become one of the main goals for the company, which increased the competitiveness of products that the Ukrainian equipment manufacturer lacks.

To successfully promote products on the market and meet the needs of customers, it is necessary to innovate the development of the enterprise and its adaptability to the rapidly changing market requirements. The authors agree with the opinion of E.P. Ruffoni & F.M. Reichert (2022), who determined that rural machinery manufacturers innovate through the use of two combinations of possible expansion: development, operational activities and management, or operational activities and transactions. According to the researchers, innovation is possible only if you supplement production excellence by improving existing products and management processes, or by improving negotiation skills and commercialisation processes. For implementation in the field of agricultural engineering of Ukraine, the paper by P. Niewiadomski *et al.* (2019) is aimed at determining the level of maturity of technical culture in enterprises. The criterion for the maturity of technical culture is compliance with the principles of lean production. The developed methodology can be useful for the self-assessment and orientation of enterprises seeking to increase maturity and implement lean manufacturing.

In continuation of the theme of the maturity of technical culture, B. Nogalski *et al.* (2020) argue that mature enterprise business models must adapt quickly to unexpected and unpredictable market changes. The researchers justify the expediency and purposefulness of implementing such business models at the enterprise, which is aimed at the strategic perspective of adaptation

to the market. The need for this adaptation is dictated by the specifics of high competition in the agricultural machinery market at the local, national, and international levels. N.I. Boltyanskaya & O.V. Boltyansky (2020) argue that almost half (about 38%) of Ukrainian-made equipment does not meet the regulatory and technical requirements during testing, more than 63% of tested machines fail within 10-100 hours, and 16% of equipment does not meet the requirements of occupational safety. Before the start of full-scale military operations in 2022, a significant number of enterprises actively introduced innovations in production and improved the quality of their products. Thus, at the end of 2019, “Elvorti”, a company that produces tillage and sowing equipment, entered the top 50 innovative companies in Ukraine due to the use of Toyota's lean manufacturing principles. The company's savings from reducing electricity and heating costs amounted to about UAH 1.5 million per year (TOP-50 innovative..., 2019). Kharkiv Tractor Plant aimed to create a powerful industrial park on its own production base, the key resident of which was to be KHTZ. The technopark's activities were also aimed at developing IT technologies, logistics, trade, educational and other clusters (Employees of Kharkiv..., 2022). At the present stage of development of the agricultural machinery industry in Ukraine, its products are mostly not competitive in comparison with the products of the world's best manufacturers, strong production and human resources potential, investments and state assistance will allow it to reach the appropriate level.

► Conclusions

The regional location of agricultural engineering enterprises is based on the principles of proximity to the raw materials and energy base, human resources and sales markets, that is, most of the enterprises are located in the eastern and southern regions – Zaporizhzhia (120 units), Kharkiv (67 units), and Dnipropetrovsk (61 units). The largest share of individual entrepreneurs is in Khmelnytskyi (14 enterprises, 56.0%), Poltava (11 enterprises, 44.0%), Cherkasy (11 enterprises, 40.7%) and Kharkiv (27 enterprises, 40.3%) oblasts. The majority of enterprises in the industry are classified as “small” – from 85.8% in 2012 to 91.5% in 2021, and the majority of employees in the industry are employed in “medium” enterprises – from 59.1% in 2010 to 79.3% in 2016. There is a general tendency to reduce the number of employees in agricultural engineering enterprises and increase their share in small enterprises, which leads to a decrease in the volume of equipment production and deterioration of its quality. Military operations caused a decrease in the number of active enterprises by 30 units as of November 1, 2022, compared to their number as of November 1, 2021.

A study of the dynamics of profitability of enterprises in the industry indicates a low efficiency of its activities. In general, the industry was unprofitable until 2016 – total losses amounted to UAH 35.6 million. The main factor behind the industry's profitability growth was the introduction in 2017 of a partial compensation programme for the cost of domestically produced agricultural machinery and equipment, which significantly increased sales and, consequently, profit – in 2021, the industry's profitability was UAH 849.3 million. Due to the lack of production potential,

Ukraine is not able to provide its own agricultural production with combine harvesters – with the import of 3229 units in 2017, its own production was only 70 units. The most promising for the Ukrainian agricultural engineering industry is the production of seed drills – the maximum volume of their production was 7367 units in 2011, and the minimum – 3220 units in 2019. The production of sowing machines in Ukraine has a strong export potential and a greater level of diversification in the markets than other types of equipment. After 2019, export flows were directed to the United States – 2220 units (44.2%) in 2022 and to Moldova – 1079 units (63.4%) in 7 months of 2023.

The production of tillage equipment mainly does not require innovative technologies and highly qualified personnel. The maximum production volumes of this type of equipment were observed in 2011 – 15 403 ploughs, 7421 disc harrows, and 7396 cultivators. There is a general tendency to reduce the production of plows due to the active introduction of dump-free technologies. In 2021, Ukraine experienced a fairly high level of competitive advantages

only in relation to tillage equipment (including sowing equipment) – 1.802, the lowest indicator for tractors – only 0.034. The correlation between tractor production and export for the period 2010-2021 is high ($r=0.8982$). The coefficient of determination $R^2=0.8069$ indicates a high dependence of tractor production volumes on their export volumes.

The prospect of further study is to investigate the sale of agricultural machinery as an important element of market relations. The study will include an analysis of the activities of enterprises and structures that sell equipment and its service, the effectiveness of their activities and the impact on the field of war sales, and determining ways to develop trade in the post-war period.

► Acknowledgements

None.

► Conflict of Interest

The authors declare no conflict of interest.

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Виробництво як ланка ринку сільськогосподарської техніки для рослинництва України

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► **Анотація.** Виробництво сільськогосподарської техніки та обладнання в Україні є одним з основних джерел наповнення ринку матеріально-технічних ресурсів для аграрного виробництва, але станом на 2023 рік не повною мірою задовольняє його потреби. Відповідно до актуальності порушеної проблеми, метою роботи було дослідження тенденцій розвитку галузі сільськогосподарського машинобудування в Україні у динаміці, впливу на нього воєнних дій та опрацювання ефективних шляхів подолання їх негативних наслідків. У процесі дослідження були використані наступні методи: діалектичний, статистико-економічний, графічний, індексний, кореляційно-регресивного аналізу, емпіричний, порівняльного аналізу, аналітичного прогнозування, абстрактно-логічний тощо. Визначено принципи регіонального розміщення підприємств сільськогосподарського машинобудування залежно від наявності сировинної бази, енергетичних та трудових ресурсів. Визначено структуру підприємств галузі за категоріями – більшість з них складають малі підприємства (85,8-91,5 %), але більшість працівників припадає на середні підприємства (59,1-79,3 %). Через військові дії кількість активних підприємств галузі скоротилася приблизно на 30 одиниць. Виявлено тенденцію щодо скорочення виробництва в Україні тракторів, комбайнів та деяких видів ґрунтообробних машин та причини його виникнення. Обґрунтовано перспективність виробництва в Україні техніки для посіву. Проаналізовано індекс виявлених порівняльних переваг різних країн за окремими видами техніки, виявлено, що в Україні лише техніка для обробки ґрунту має високий рівень переваг – 1,802 та має оптимістичні перспективи розвитку. У роботі визначено тісний кореляційний зв'язок між експортом та виробництвом тракторів в Україні у 2010-2021 рр. (відповідний коефіцієнт кореляції склав 0,8982). Встановлено проблеми, що гальмують розвиток галузі сільськогосподарського машинобудування: інфляція, порушення логістичних зв'язків та втрата постачальників, високі ціни на енергетичні ресурси тощо. Запропоновано рекомендації щодо їх подолання: створення сприятливих інвестиційних умов; здійснення протекціоністської митної та податкової політики для підприємств галузі; евакуація їх із зони бойових дій. Запропоновані заходи сприятимуть відновленню, збереженню та поступальному інноваційному розвитку потенціалу українського сільськогосподарського машинобудування

► **Ключові слова:** сільськогосподарське машинобудування; експорт; прибуток; розміщення підприємств; імпорт; ґрунтообробна техніка



UDC 336.025:636.2.034

Trends in the development of dairy farming and its state financial support in Ukraine

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► **Abstract.** The importance of dairy farming for food security and the formation of added value in agriculture necessitates a rational combination of market self-regulation mechanisms and instruments of state intervention in economic processes in the sector. The purpose of this study was to assess the development of dairy farming in Ukraine and identify ways to improve its state support. The following methods of scientific cognition were employed in the study: analysis and synthesis, induction and deduction, abstract-logical, historical, comparative analysis, monographic, computational-constructive, graphical, tabular, statistical analysis, generalisation, causal and retrospective analysis, analytical alignment of time series, economic modelling, and forecasting. Based on the results of using these methods, the study summarised the current trends in the development of dairy farming in Ukraine and its state financial support using tax and budgetary regulation instruments. The study covered the specifics of the existing structure of dairy farming in Ukraine, which, unlike the countries of the European Union, is represented by three categories of economic entities. It was found that since the early 2010s, Ukraine has been experiencing processes of concentration in the field of dairy farming. The study found a direct correlation between the size of the number of cows kept and the profitability of dairy farming. It was determined that enterprises with up to 100 cows gradually reduce the volume of activities in the dairy farming sector due to its unprofitability. The study assessed changes in the structure of dairy farms in European countries from the mid-1990s to the early 2020s and found that they are also characterised by trends in the concentration of dairy farming. The efficiency of the state financial support for the development of dairy cattle breeding in Ukraine through the instruments of tax and budgetary regulation in the pre-war period and in the martial law regime was assessed. The paper described the advantages and disadvantages of the applied instruments of budgetary support for dairy farming, substantiated proposals for the use of instruments of tax and budgetary stimulation of dairy farming development in the period of post-war economic recovery of Ukraine, considering the existing trends in the development of dairy farming in Ukraine. The practical significance of this study lies in the possibility of using the obtained results in the drafting of policy documents on the post-war development of the agro-industrial complex of Ukraine in general and specifically its dairy subcomplex

► **Keywords:** dairy sector; state regulation; structure of dairy farms; fiscal policy; budget support programmes; categories of milk producers

► **Suggested Citation:** Tulush, L., Hryshchenko, O., & Strikhovskyi, D. (2023). Trends in the development of dairy farming and its state financial support in Ukraine. *Ekonomika APK*, 30(5), 33-45. doi: 10.32317/2221-1055.202305033.

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► Introduction

The development of dairy farming at the global, regional, and national levels is traditionally on the agenda of government agencies, international professional and non-governmental organisations. The dairy industry generates significant employment and provides financial livelihoods for many economic entities, which requires constant monitoring of existing trends and outlining further prospects for its development. The Global Dairy Platform facilitates sectoral discussions on best practices in milk production and processing, as well as the exchange of information on trends and potential trajectories for the development of the dairy industry globally, in specific regions and in countries/groups of countries (2018 Annual review, 2019).

The relevant issues are also constantly in the focus of attention of the academic community – a many scientists investigate the issues of generalising the existing trends in the development of the dairy farming sector, systematically monitoring changes in the structure of the dairy sector in individual countries, groups of countries or regions, as well as changes in the efficiency of milk production. J.H. Britt *et al.* (2018) try to predict the trajectory of the global dairy industry in the long term. According to their forecasts, the size of dairy farms will increase substantially, and milk production will be considerably modernised through the active introduction of the latest technologies and innovative practices. R. Bhat *et al.* (2022) also address the need to control the structural features of dairy farms. W. Poczta *et al.* (2020) note that the economic situation on dairy farms in the European Union (EU) varies substantially between countries and emphasise that medium and large highly specialised intensive farms play an increasingly important role in milk production, as they are characterised by high productivity levels. T. Zinchuk *et al.* (2022) analyse the factors that have led to structural changes in Swiss dairy farming. J.M. MacDonald *et al.* (2020) describe the structural transformation of dairy farming in the United States, noting the factors that led to it and assessing the prospects for further consolidation in the sector.

Dairy farming has been the leading livestock sector in Ukraine, despite the complexity of the business due to its high capital intensity, long payback period, and elevated level of risks – from cow husbandry to the need to process perishable raw milk quickly. Therewith, the dairy sector in Ukraine has been undergoing substantial structural changes since the early 2010s, which need to be considered when developing the instruments of state financial support.

The importance of dairy farming for Ukraine's food security necessitates the formation and continuous review of the state support policy for this sector of the agri-food complex, primarily through tax and budgetary regulation. Before the full-scale Russian invasion, Ukraine had developed a certain toolkit of state financial support for dairy farming. However, considering the substantial decline in the performance of Ukraine's dairy sector, it proved insufficient – especially in terms of stimulating the activities of small milk producers. Furthermore, the conditions of post-war economic recovery and Ukraine's

European integration require modernisation of the existing tools to stimulate the development of the dairy sector in Ukraine.

At the same time, a rather limited number of scholars are concerned with the issues of comprehensive assessment of the effectiveness of state financial support for the development of dairy farming in Ukraine. A. Semsal & S. Shupyk (2021) note that state financial support plays a vital role in shaping the motivation of agricultural producers to increase milk production.

S. Shupyk (2021) tried to substantiate a set of financial regulation measures at the state and regional levels, which can provide incentives for the revival of the dairy farming sector in Ukraine. A similar goal is pursued by a team of authors (Svynous *et al.*, 2022), who, based on an assessment of the existing instruments of state financial support for dairy farming in Ukraine, are trying to substantiate the most effective forms of state financial support for it.

Ukraine lacks comprehensive research on the effectiveness of state financial support for dairy farming. This is particularly relevant considering the challenges faced by the sector due to Russian aggression. It is necessary to define the role of the dairy sector in ensuring the country's food security and develop a system of state incentives for its development. Existing approaches to financial incentives for the development of the dairy industry need to be clarified and modernised. The purpose of this study was to summarise the trends in the development of the dairy sector of the Ukrainian agro-industrial complex (AIC) and to analyse the effectiveness of state support to develop proposals for further improvement of this sector.

► Materials and Methods

This study was conducted using a set of general scientific and economic and statistical methods. Specifically, by applying the methods of causal and retrospective analysis, the author summarises the trends in the development of the dairy farming sector of Ukraine before the beginning of the Russian armed aggression and the impact of the state financial support measures on them, and also identifies certain stages within which the trends changed. Using a systematic approach, the interrelationships between the processes that took place in the field of dairy farming during the study period (2004-2023) were identified.

Methods of generalisation and graphical presentation of information were used to find trends and patterns of development of the dairy farming sector in Ukraine. To formalise the existing trends and determine the trend equation, the study analytically aligned the indicators of the number of cows, their productivity, and milk production volumes based on economic and statistical assessment of the dynamics of their change. Given the multidirectionality of the trends during the period under study, to ensure greater accuracy in formalising the trends, it was divided into two sub-periods for which the relevant trend equations were determined. To determine the trend equation, a power function was chosen because it is best suited to formalise trends with varying degrees of

proportionality of changes over time, which was the case in the Ukrainian dairy sector during the study period:

$$Y = a \times t^b, \quad (1)$$

where Y is the calculated (theoretical) value of the resultant attribute; a and b are the parameters of the equation, t is the period number ($t=1, \dots, n$), n is the number of years.

The parameters of the trend equations were estimated using the least squares method, the main condition of which is to minimise the sum of squares of deviations of the factual values of the factor attribute (Y) from its theoretical (average) value determined by the trend equation.

The assessment of structural changes in the dairy farming sector of Ukraine was carried out using the methods of grouping and tabular presentation of information. The study identified the performance indicators of enterprises that kept up to 100 and more than 500/1000 cows, and, accordingly, determined their shares in the total number of cows, the total volume of milk produced, and conducted a comparative analysis of cow productivity in agricultural enterprises depending on the number of cows they keep. The same methods were used to estimate the relationship between dairy farm size (number of cows), productivity, profit per cow, and profitability of milk production activities.

When assessing the changes in the structure of dairy farms in the EU countries with developed dairy farming and the USA, the methods of grouping and comparative analysis were used. For this purpose, the study used the cow population scales applied by the International Farm Comparison Network (IFCN Dairy Report 2021, 2022). The use of the method of analytical data processing helped to characterise the trends of structural changes in dairy farming in these countries, and the use of the method of comparative analysis made it possible to compare them with the relevant trends in the dairy farming sector of Ukraine.

To characterise the instruments of tax and budgetary regulation of the development of the dairy farming sector in Ukraine, the study used the methods of retrospective analysis and generalisation of provisions of regulations on the state financial support for the development of the agro-industrial complex. The effectiveness of the existing budget programmes to support the development of dairy farming in Ukraine was assessed based on analytical and expert study of the indicators of their implementation passports. Trends in the state financial support for the development of livestock in general, and dairy farming specifically, during martial law are summarised based on analysis and expert assessment of the provisions of the regulations governing the relevant relations in Ukraine. The methods of economic modelling and scientific generalisation were used to comprehensively assess the effectiveness of the existing instruments of tax and budgetary regulation of dairy farming in Ukraine. The method of economic forecasting was used to outline further prospects for the development of dairy farming in Ukraine and to improve approaches to its fiscal incentives. The areas of modernisation of the instruments

of state financial support for the development of dairy farming in Ukraine are formed by using the abstract-logical method.

The information and analytical framework for this study included the following: regarding Ukraine – statistical materials of the State Statistics Service of Ukraine, which characterise the state of development of dairy farming in Ukraine (specifically, Livestock in Ukraine 2021, 2022); for the EU and the USA – analytical materials of international professional organisations in the dairy farming sector and research groups under governmental structures (specifically, IFCN Dairy Report 2021, 2022; Dairy Market Review..., 2022; Augère-Granier, 2018).

The study was also based on the assessment of Ukrainian legislation on state financial support for dairy farming, namely, the Law of Ukraine No. 1877-IV "On State Support of Agriculture in Ukraine" (2004) and sub-legislative acts (namely, Resolution of the Cabinet of Ministers of Ukraine No. 107..., 2018) developed to implement its provisions, as well as data from the passports of budget programmes aimed at supporting the development of agricultural producers in Ukraine (Information on the implementation..., n.d.).

► RESULTS

A retrospective analysis of the development of the dairy farming sector. Since the early 2000s, the volume of activities of agricultural enterprises in the dairy farming sector has been declining substantially, despite the state financial support measures applied by the government during this period: both through budget subsidies and tax incentives (specifically, the application of a special regime for the collection of value added tax (VAT) – the so-called VAT subsidies, zero VAT rate for taxation of transactions involving the supply of milk by households for industrial processing).

The reason for the decline and stagnation of Ukraine's dairy sector in 2000-2010 in the segment of agricultural enterprises was the substantially lower profitability of milk production compared to the production of high-margin export-oriented crops (primarily grain/oilseeds and maize). As a result, the dairy sector was less attractive for agricultural businesses, which led most agricultural enterprises to either curtail their activities or not prioritise it when planning their development and approving their investment projects.

In the first half of the 2010s, the decline in the development of dairy farming in Ukraine in the segment of agricultural enterprises stopped: the number of cows still continued to decline, but due to the dynamic growth of cow productivity – as a result of improved cow husbandry technology – milk production in this category of producers was more or less stable, fluctuating within 2.6-2.8 million tonnes (Fig. 1). The volume of households' activities in the dairy farming sector has been steadily declining since the early 2000s. Therewith, while the rate of decline in the number of cows in the household segment averaged 4.8% per year until the mid-2010s, it increased to 7.2% in 2016-2021. The rate of reduction in milk production volumes in the household sector did not exceed 3% annually on average until the mid-20XX, but after 2016, it increased to over 5%.

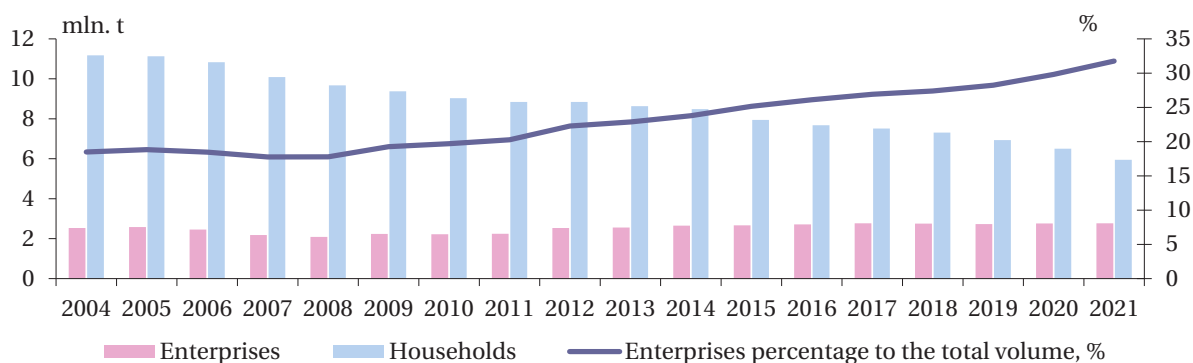


Figure 1. Dynamics of milk production in Ukraine by individual categories of producers before the start of full-scale Russian military aggression, million tonnes

Source: completed by the authors of this study based on Livestock in Ukraine 2021 (2022)

To formalise the existing trends in the development of the dairy sector in Ukraine, an analytical alignment of the indicators of the available number of cows, their productivity, and milk production in the entire Ukraine and by individual

categories of producers in 2004-2021 was carried out (Table 1). Based on the economic and statistical assessment of changes in the existing trends in the development of the dairy farming sector, the relevant trend equations were formed.

Table 1. Results of the analytical alignment of trends in indicators number of cows, their productivity and milk production in Ukraine

Period	Indicator	Trend equation	Reliability coefficient (R^2)	Forecast value for 2023
All categories of farms				
2004-2011	Number of cows	$Y_1 = 4091.7t^{0.2172}$	0.9682	x
	Cow productivity	$Y_2 = 3167.3t^{0.1269}$	0.9636	
	Milk production volumes	$Y_3 = 14\,348t^{0.1166}$	0.8765	
2012-2021	Number of cows	$Y_1 = 2762t^{0.2058}$	0.8678	1635
	Cow productivity	$Y_2 = 4244.6t^{0.0763}$	0.914	5131
	Milk production volumes	$Y_3 = 11\,984t^{0.1045}$	0.7852	9245
Agricultural enterprises				
2004-2011	Number of cows	$Y_1 = 985.12t^{0.2616}$	0.9698	x
	Cow productivity	$Y_2 = 2425.5t^{0.2389}$	0.931	
	Milk production volumes	$Y_3 = 2592.6t^{0.0868}$	0.6262	
2012-2021	Number of cows	$Y_1 = 603.13t^{0.1444}$	0.9344	421
	Cow productivity	$Y_2 = 4384.7t^{0.1725}$	0.9089	6731
	Milk production volumes	$Y_3 = 2521.7t^{0.0425}$	0.9266	2804
Households				
2004-2011	Number of cows	$Y_1 = 3106.5t^{0.2038}$	0.9598	x
	Cow productivity	$Y_2 = 3399.4t^{0.0964}$	0.9675	
	Milk production volumes	$Y_3 = 11\,759t^{0.1238}$	0.8672	
2012-2021	Number of cows	$Y_1 = 2162.6t^{0.2256}$	0.842	1225
	Cow productivity	$Y_2 = 4234.3t^{0.0377}$	0.9014	4665
	Milk production volumes	$Y_3 = 9529.8t^{0.1564}$	0.8053	6441

Note: Y is the outcome variable (Y_1 is the number of cows (in the corresponding period for the corresponding category of producers); Y_2 is the cow productivity (in the corresponding period for the corresponding category of producers); Y_3 is the milk production (in the corresponding period for the corresponding category of producers); t is the factor attribute (period number), $t = 1; n$ is the number of years

Source: completed by the authors of this study based on Livestock in Ukraine 2021 (2022)

Therewith, the relevant period was divided into two – in the first, performance indicators in dairy farming declined in all categories of farms (2004-early 2010). In the second case, only households saw a decline in milk production. Proceeding from the data in Table 1, the power

coefficient in the trend equation for the 1st period to formalise the indicators characterising the change in milk production was (-0.1166), and for the 2nd period – (-0.1045). Thus, the rate of decline in milk production did not differ significantly between the two sub-periods.

Considering the equation for changes in milk production by individual categories of milk producers, the situation is substantially different: for agricultural enterprises, the power coefficients are (-0.0868) and 0.0425, respectively; for households, (-0.1238) and (-0.1564). Thus, in 2004-2011, milk production in agricultural enterprises was declining, with a negative power law value almost 1.5 times higher than that of households. Since 2012, milk production in the agricultural segment has generally not declined, with a rather low degree of trend equation. On the other hand, the negative power law value of the trend equation for households decreased by more than a quarter for 2012-2021. As a result, the share of agricultural enterprises in total milk production increased from 18.3% in 2004 to almost 32% in 2021.

Predicting total milk production in Ukraine, even in the short term, is virtually impossible, both given the trends that began in the sector in the late 2010s and the Russian military aggression (Lupenko *et al.*, 2022). Thus, the calculated indicators of the development of the dairy sector of Ukraine in 2022, using the obtained trend equations in terms of certain categories of milk producers and periods, turned out to be relevant only for agricultural enterprises – subject to adjustment for the factor of the Russian military invasion, which led to a decrease in milk production in the segment of agricultural enterprises by 5.3% (Agriculture of Ukraine for 2022, 2023).

The factor of Russian military aggression had the greatest impact on the performance of households. Furthermore, the dynamics of these indicators in the second half of the 2010s and early 2020s was shaped by the new state dairy policy, which substantially tightened the requirements for milk supplied for industrial processing. Households using imperfect dairy technologies will be unable to supply milk for industrial processing, and thus will lose the relevant income channel, and with it the motivation to keep cows for additional income.

Currently, it is expected that starting from about 2025, Ukrainian dairy processing enterprises will completely abandon the use of milk produced by households, if it does not meet the approved safety and quality requirements (Order of the Ministry of..., 2019). Given this, in the short term, agricultural enterprises will need to promptly increase the volume of milk supplied by households for industrial processing to prevent a decline in milk processing.

To assess structural changes in the Ukrainian dairy farming sector in the segment of agricultural enterprises, the relevant groupings and structuring of dairy farms were carried out depending on the number of cows available, their productivity and share in total milk production over the pre-war twelve years (2010-2021), during which milk production in the segment of agricultural enterprises stabilised (Table 2).

Table 2. Structure of dairy cattle breeding in agricultural and farm enterprises

Indicators	2010	2015	2021	2021 to, p.p.		2022 for reference
				2010	2015	
Number of enterprises that kept cows, units	3741	2614	1686	45.1	64.5	1440
Number of cows in agricultural enterprises, thous. heads	589.1	505.1	424.6	72.1	84.1	394.2
Share of enterprises that held (%):						
– up to 100 cows	55.4	50.2	43.8	-11.6	-6.4	42.5
– over 500 cows	7.2	9.6	13.7	6.5	4.1	14.9
– incl. over 1000 cows	1.2	2.4	4.8	3.6	2.4	5.1
Share of cows owned by enterprises (%):						
– up to 100 cows	10.0	7.9	5.6	-4.3	-2.2	5.9
– over 500 cows	36.3	43.5	52.5	16.9	9.0	54.0
– incl. over 1000 cows	11.3	18.9	28.9	17.7	10.0	30.3
Share of milk produced by cows owned by agricultural enterprises (%):						
– up to 100 cows	5.8	5.2	4.1	-1.7	-1.1	...
– over 500 cows	45.4	49.7	61.4	16.0	11.7	...
– incl. over 1000 cows	14.2	21.5	34.1	19.9	12.6	...
Productivity of cows in agricultural enterprises (kg):						
– up to 100 cows	2190	3496	4804	219	137	...
– over 500 cows	4712	6035	7618	162	126	...
– incl. over 1000 cows	4736	6005	7687	162	128	...
For reference: number of cows per 1 enterprise that kept them, heads	157	193	252	160	130	274

Source: compiled by the authors of this study based on Livestock in Ukraine 2021 (2022); Agriculture of Ukraine for 2022 (2023)

As the data presented in Table 2 shows, the situation in the Ukrainian dairy farming sector has changed substantially in recent years before the full-scale Russian invasion, with concentration processes taking place in the

sector, which will only intensify in the context of the post-war economic recovery. Thus, there is a trend towards concentration of dairy farms in Ukraine, as it is more cost-effective to keep more cows due to economies of

scale. The results of the grouping and structuring of dairy farms in terms of the number of cows kept, their average

productivity and profitability in the dairy farming sector are presented in Table 3.

Table 3. Grouping and structuring of agricultural enterprises engaged in dairy farming according to the number of cows held

Groups according to number of cows, heads	Number of farms in the group	The share of the number of enterprises, %	Share in total cow livestock, %	Share of milk, %	Milk yield per 1 cow, kg	Profit per cow, UAH	Profitability, %	Share of milk in revenues, %
2010								
up to 100	1006	41.8	8.9	6.2	2765	13.4	0.3	5.3
101-300	915	38.0	31.8	26.5	3323	925.7	14.6	16.6
301-500	268	11.1	19.6	20.2	4118	1 591.7	19.4	25.2
501-1000	173	7.2	22.2	26.2	4693	2 457.2	24.6	28.0
over 1000	44	1.8	17.6	20.9	4736	1 710.8	16.4	26.5
Total	2406	100.0	100.0	100.0	3981	1 452.5	17.9	20.0
2016								
up to 100	501	32.9	5.5	3.6	3688	326.7	2.3	3.5
101-300	581	38.2	23.7	19.3	4562	2 490.1	13.1	10.3
301-500	225	14.8	18.9	19.0	5642	4 494.9	18.5	17.2
501-1000	144	9.5	21.0	25.1	6678	6 176.9	20.8	21.0
over 1000	70	4.6	30.9	33.1	5995	5 706.5	20.5	16.7
Total	1521	100.0	100.0	100.0	5606	4 520.6	18.3	14.5

Note: 2016 is the last year for which such calculations can be made (due to a substantial reform of statistical reporting of agricultural enterprises)

Source: completed by the authors of this study based on Livestock in Ukraine 2021 (2022)

As Table 3 shows, there is a relationship between dairy farm size and profitability of milk production, with higher profitability for those farms that keep more cows. Therewith, dairy farming activities of enterprises with up to 100 cows were factually unprofitable. As a result, dairy farms with a small number of cows are gradually ceasing to operate, resulting in a rapid decline in the number of enterprises with less than 100 cows in Ukraine.

This trend should be considered when forming state financial support for the development of dairy farming. In

the context of the post-war economic recovery in Ukraine, it is necessary to ensure that state financial support resources are concentrated on economically powerful dairy farms. The concentration of dairy farming is an objective trend inherent in the dairy farming industry of most countries with developed dairy farming, including European countries and the United States (Table 4). To better illustrate the structural changes in the dairy sector of these countries, a period of a quarter of a century was chosen – from the mid-1990s to 2020 inclusive.

Table 4. Changes in the structure of dairy farms in selected European countries with developed dairy farming and the USA (2020 vs 1996), %

EU as a whole			Lithuania			Denmark			Germany		
Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020
1-2	16	4	1-2	55	10	up to 50	37	1	up to 9	5	1
3-10	13	4	3-9	31	15	51-100	48	7	10-19	14	2
11-30	18	10	10-19	2	10	101-250	13	33	20-29	17	5
31-100	34	32	20-29	1	7	250-500	2	30	30-49	23	10
101-300	10	33	30-99	2	25	501-1000	0	19	50-99	21	26
over 300	9	17	over 100	11	33	over 1000	0	10	over 100	20	56
France			Netherlands			Poland			USA		
Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020
up to 9	5	1	up to 9	0	0	up to 9	90	15	1-49	18	4
10-19	10	3	10-29	11	2	10-19	8	17	50-199	45	16
20-29	17	3	30-49	27	5	20-99	2	52	200-499	15	10
30-49	38	12	50-99	50	33	100-199	0	10	500-999	8	10

Table 4, Continued

France			Netherlands			Poland			USA		
Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020	Headcount	1996	2020
50-99	28	47	over 100	12	60	over 200	0	6	1000-2500	9	19
over 100	2	34							over 2500	5	41

Source: calculated according to the data from IFCN Dairy Report 2021 (2022)

As the data in Table 4 shows, between the mid-1990s and 2020, there were substantial changes in the structure of dairy farms in European countries, namely, the concentration of dairy farming. While in the EU in total in the mid-1990s, almost half of the cow livestock was owned by entities with no more than 30 cows, in 2020 the share of the corresponding livestock fell to 18%. On the other hand, the share of livestock owned by entities with more than 100 cows increased from 19% to 50%. As a result, as of the early 2020s, more than half of the cow livestock in the EU on average was owned by entities with more than 100 cows. Moreover, the share of livestock owned by entities with more than 100 cows increased over the study period: in Lithuania – up to 33%; in Denmark – 92%; in Germany – 56%; in France – 34%; in the Netherlands – 60%.

Poland's experience is quite specific: in the mid-1990s, the number of cows owned by entities with up to 10 cows exceeded 90% of the total number of cows, and there were no farms with more than 100 cows at all. In contrast, in 2020, the share of livestock owned by entities with up to 10 cows decreased to 15%, while the share of livestock on farms with 20 to 100 cows increased from 2% to 53%. Furthermore, more than 15% of the cow livestock was owned by entities with more than 100 cows.

The United States has developed its own model of the dairy sector, which relies on large dairy farms. While in the mid-1990s the share of cows owned by entities with more than 1,000 heads was less than 15%, in 2020 it rose to 61%. The share of cows owned by entities with less than 100 cows decreased from 63% in the mid-1990s to less than 20% in 2020.

The impact of state financial support measures on the development of dairy farming. The analysis of the information sources used shows that dairy farming is conventionally subject to state financial regulation. Accordingly, most countries or supranational entities allocate significant amounts of financial resources to stimulate its development. Before the start of the full-scale Russian military aggression, Ukraine was no exception in this regard, with considerable attention being paid to the issues

of state financial support for the development of the dairy industry in Ukraine.

Until 2017, state support for the development of dairy farming in Ukraine was for a long time mainly provided through the application of a special VAT regime for the taxation of transactions involving the supply of raw milk (as well as other types of agricultural products) – the so-called VAT accumulation regime (Tulush, 2017). Under the terms of this special regime, the VAT liabilities due to the state budget stayed at the disposal of milk producers and were used by them to finance expenses related to the development of dairy farming. The use of this specific instrument of state financial support substantially increased the amount of own financial resources at the disposal of milk producers – on average by 8.5-9.0% of their income.

Since 2017, the special VAT regime for taxation of transactions on the supply of certain types of agricultural products has been completely cancelled, but a slightly modified instrument of state financial support – the so-called quasi-accumulation (refund) regime – has been proposed following Article 16-2 of the Law of Ukraine No. 1877-IV “On State Support of Agriculture in Ukraine” dated 24.06.2004 (2004). This instrument made provision for the refund of a part of the VAT liabilities paid to the budget by business entities within the scope of the budget subsidy for financial support of agricultural producers to stimulate the production of certain types of agricultural products (including milk), prescribed in the relevant budget programme of state support (Tulush, 2017). The respective area of budget support was an “umbrella” one, i.e., it concerned many types of agricultural products aimed at filling the domestic market (livestock products, fruits, vegetables, berries). However, after 2017, the relevant direction of state financial support for agricultural producers was not applied, although as of 2023 it is prescribed in Law No. 1877-IV (Law of Ukraine..., 2004).

The dynamics of budget financing for the development of dairy farming in Ukraine in terms of individual instruments of state financial support used in 2018-2021 is presented in Table 5.

Table 5. Budget financing of dairy farming development needs in Ukraine in terms of individual instruments of state financial support in 2018-2021, UAH million

Budget support instruments	2018	2019	2020	2021
<i>Instruments of the direction “State support for livestock development and processing of agricultural products”</i>				
Partial reimbursement of the cost of purchased breeding animals, sperm, embryos (“umbrella” area)	214.6	150.2	300.0	527.5
Partial reimbursement of the cost of construction/reconstruction of livestock facilities and agricultural processing facilities (“umbrella” area)	1 278.7	526.0	430.6	941.1
Special budgetary subsidy for cows	512.1	531.2	x	x
Special budget subsidy for keeping young cattle in households	321.2	615.4	x	x
Special budget subsidy for the increase in the number of cows of own reproduction	x	x	x	100.0

Table 5, Continued

Budget support instruments	2018	2019	2020	2021
Partial compensation of the cost of construction/reconstruction of livestock farms and agricultural processing enterprises in terms of costs financed by bank loans (<i>"umbrella" area</i>)	63.1	75.2	1.8	17.4
<i>Tools of the area "State support for the development of farms"</i>				
Special budgetary subsidy for cows	x	x	35.2	57.6

Source: compiled according to data from Information on the implementation of budget program passports (n.d.)

As Table 5 shows, Ukraine used a variety of instruments to promote dairy farming in the years before the Russian invasion. Some of them were used on a regular basis, while the state almost immediately abandoned the use of certain instruments and replaced them with new ones. Some of the instruments were developed for the dairy sector only, but most of them were "umbrella", i.e., available to business entities engaged in any type of livestock production (poultry farming, pig husbandry, beekeeping, etc.).

It is worth noting the small amounts of budget allocations to support the development of the dairy sector in these years: about UAH 0.5 billion in 2020 and less than UAH 0.7 billion in 2021 (in 2018-2019, the amounts of budget support were slightly higher – UAH 1.7 and 1.5 billion, respectively). Given that the cost of raw milk in 2020-2021 exceeded UAH 100 billion, the budget allocations to support the development of dairy farming can be considered insufficient, as they did not exceed 0.5% of the cost of raw milk, and therefore could not have a substantial impact on the development trajectory of the dairy farming sector in Ukraine. In the years before the Russian invasion, partial reimbursement of the cost of purchased breeding animals, semen, and embryos, as well as partial reimbursement of the cost of construction/reconstruction of livestock facilities and agricultural processing facilities, were conditionally permanent instruments of budget support for the development of dairy farming in Ukraine.

According to clause 8 The procedure for the use of funds provided in the state budget for budgetary support for the development of animal husbandry and processing of agricultural products, approved by Resolution of the Cabinet of Ministers of Ukraine No. 107 dated February 7, 2018 (Resolution of the Cabinet of Ministers of Ukraine No. 107..., 2018) partial reimbursement of the cost of breeding animals, sperm, and embryos was provided to economic entities for purchased heifers, cows, and other types of farm animals, sperm, and embryos of cattle in the amount of up to 80% of the cost (excluding VAT). Thus, the relevant area was "umbrella", i.e., it applied not only to cattle breeding but also to other types of livestock. The use of such a broad approach to forming a circle of recipients within one area of budget support made this instrument unpredictable. Quotas for certain areas of livestock activities were not prescribed, and no priority was given to certain types of activities in the distribution of budget support. As a result, if the amount of applications exceeded the amount of budget allocations, the amount of budget support was distributed proportionally, i.e., as a certain share of the application, within the factual amount of budget allocations. Furthermore, the maximum amount of support per animal was determined, specifically, for breeding heifers, cows purchased in Ukraine – 50.4 thousand per head.

According to the passport of the budget programme "Financial Support to Agricultural Producers" for 2021, the

sub-area "Partial reimbursement of the cost of purchased breeding animals, semen, embryos" (planned annual funding of UAH 350 million) of the area "State support for the development of livestock and processing of agricultural products" (planned annual funding of UAH 1150 million), it was planned to stimulate the purchase of 4.5 thousand heads of cows (heifers, calves), 130 thousand doses of bull semen, and 50 cattle embryos (Passports of budget programmes for 2021, 2022). As a result of the relevant measures, it was planned to increase the average milk yield per cow by 1% compared to the previous year and increase the number of cows in agricultural enterprises by 0.5% compared to the previous year. The planned increase in the number of cows was not achieved, and productivity growth occurred regardless of the government's incentives, due to the improvement of milk production technologies by dairy businesses.

Another conditionally permanent instrument of budget support was a partial reimbursement of the cost of construction/reconstruction of livestock facilities and agricultural processing facilities. According to paragraph 9 (Resolution of the Cabinet of Ministers of Ukraine No. 107..., 2018), partial reimbursement of the cost of facilities was provided in the amount of up to 50% of their cost (excluding VAT), including the cost of equipment, built/reconstructed and commissioned completed facilities for keeping animals, milking parlours, and agricultural processing enterprises.

Under the sub-area "Partial reimbursement of the cost of construction/reconstruction of livestock facilities and agricultural processing facilities" (planned annual funding of UAH 350 million) of the "State Support for the Development of Livestock and Agricultural Processing", it was planned to reimburse the cost of 30 newly built/reconstructed livestock farms and complexes (about one third of which were for keeping cattle). An increase in the number of cows in agricultural enterprises compared to the previous year's level (by 0.5%, also not achieved) was also declared as an indicator of the quality of this sub-direction of budget support (Passports of budget programmes for 2021, 2022).

Until 2020, entities that kept cattle received a special budget subsidy:

- for keeping cows – twice a year to agricultural enterprises for each identified and duly registered cow as of 1 January and 1 July of the respective year in the amount of UAH 900 per head; the respective number of cows was verified by the administrator of the Unified State Register of Animals; a refund was provided in case of a decrease in the number of cows (after receiving a budget subsidy); in case of a decrease in the number of cows, no subsidy for keeping cows was provided for the current period;

- for keeping young cattle – to households for keeping identified and registered young cattle up to 13 months of

age, which were born in households or purchased by them from other owners; the subsidy was provided for every 4 months of keeping, cumulatively, considering the age of the young cattle, in the amount of the following scheme: 1-5 months – 300 UAH/head; 5-9 months – 700 UAH/head; from 9 to 13 months – 1500 UAH/head. The total amount of the subsidy for young cattle could not exceed UAH 2500 per head; to receive the subsidy, it was necessary to submit a cattle passport, and in case of keeping 10 or more heads, an extract from the Unified State Register of Animals.

The planned amount of the special budget subsidy for cows was quite significant – UAH 700 million, but in 2018-2019, business entities were able to use only 74% and 76% of the planned budget allocations, respectively (Information on the implementation ..., n.d.). The level of support reached 2.8% of the value of raw milk received from the cow and was quite effective. However, as a result of the reform of the Agrarian Ministry in 2019 – through its merger with the Ministry of Economy – the relevant budget support instrument was lost.

The level of utilisation of the planned volumes of special budget subsidies for cattle keeping by households in 2018-2019 was 64% and 88%, respectively (in the first year, the area did not work as intended) (Information on the implementation of ..., n.d.). The support covered both dairy and beef cattle breeding and was more aimed at supporting the incomes of households engaged in these activities. The abandonment of this support instrument seemed quite logical, as it did not have much impact on the state of the dairy industry.

In 2019, a sub-area “Special budgetary subsidy for cow keeping by farms” was introduced under the “State Support for the Development of Farms” budget programme of the “Financial Support for Agricultural Producers”. In this way, an attempt was made to support the development of livestock breeding on farms. The subsidy was granted to farms that owned five or more cows, for each cow available as of 1 July of the relevant year, in the amount of UAH 5000, but not more than UAH 250 000 (i.e., the development of farms with up to 50 cows was stimulated). The level of disbursement of funds in this area left much to be desired: 35% in 2020, 58% in 2021 (Information on the implementation of..., n.d.).

Some questions arose about this area of support, since:

- ▶ the share of farms in the total number of cows kept by agricultural enterprises is insignificant and does not substantially affect the milk processing market;
- ▶ farms with up to 50 cows are not very efficient, as evidenced by the decline in the share of their livestock in the total number of cows held by this category of milk producers;
- ▶ dairy farming is not attractive for farmers – most of them are engaged in crop production and are not going to invest in dairy farming.

Considering this, the introduction of the corresponding support measure – through subsidies to farms with up to 50 cows – looked more populist and inappropriate in terms of the efficiency of spending state budget resources. Clearly, neither tactical nor strategic tasks in the dairy sector can be solved with this type of support.

In 2021, another instrument of budgetary support for the development of cattle breeding was introduced – a subsidy for the increase in the number of cows of own

reproduction (Resolution of the Cabinet of Ministers of Ukraine No. 107..., 2018). It was granted to agricultural enterprises for each available bred cow of their own reproduction, by which the main herd increased as of 1 July of the relevant year compared to the existing number of cows as of 1 January (in the amount of up to UAH 30 thousand per head). Due to the low amount of planned budget allocations in this area (UAH 100 million), the results of its implementation required the application of the proportional principle of financing, and business entities that ensured an increase in the number of cows actually received amounts 3.2 times less than those declared in the relevant procedure. This area of support is the most effective, as it encourages not just keeping cows, but increasing their number. A substantial problem with its application in 2021 was the meagre amount of budget allocations, which resulted in the factual subsidy amounts paid by the state being significantly lower than the declared amounts.

Since the beginning of Russian military aggression in February 2022, the available tools for budget support for dairy farming development have become unavailable due to the concentration of budget resources on supporting national defence. The budget programme “Financial Support for Agricultural Producers” – like other economic programmes – was “frozen” for the period of martial law and did not function in 2022-2023 (Law of Ukraine..., 2021). The imposition of martial law makes it impossible to finance economic development programmes, including the provision of state financial support to dairy farmers.

At the same time, as a result of the Russian military aggression, agricultural businesses operating in the occupied territories or near the war zone suffered significant losses. Given that representatives of micro and small agricultural businesses make a substantial contribution to the country's food security and employment in their respective areas, as well as being the main producers of agricultural products for domestic consumption, external donors decided to allocate EUR 50 million in emergency financial support to them in 2022 within the framework of the EU's budget support to Ukraine (Financial support..., 2023).

The relevant resources were allocated to the state budget for 2022 and used to support small agricultural producers under the new areas of support prescribed by Government Resolution No. 918 “On Approval of the Procedure for the Use of Funds Provided for in the State Budget for Supporting Farms and Other Agricultural Producers” of 16.08.2022 (2022), namely:

- ▶ a budget subsidy per unit of cultivated farmland (1 hectare) – in the amount of UAH 3.1 thousand per hectare, but not more than UAH 372 thousand per farm (i.e., the maximum area of farmland for which the subsidy was provided was 120 hectares);
- ▶ a special budget subsidy for the keeping of cattle (cows) – in the amount of UAH 5.3 thousand per head, but not more than UAH 530 thousand per farm (i.e., the maximum number of cattle for which the subsidy was provided was 100 heads, the minimum – 3 heads).

The new areas of support for farms and other agricultural producers were part of the new budget programme “Support for farms and other agricultural producers”, which was administered by the Ukrainian State Fund for Support of Farms and its regional offices using the State

Agrarian Register (Special budget subsidy..., 2022). The recipients of budget support were farms and other agricultural producers (including households) that had ensured that information about their agricultural activities was entered into the State Agrarian Register and had cattle registered in the Unified State Register of Animals. In 2022, a special budget subsidy for cattle (cows) was paid in the amount of UAH 329 million, which was received by 10 247 agricultural businesses for keeping 62.1 thousand cows. It was assumed that the relevant area of support – at the expense of EU budgetary support to Ukraine – would be maintained in 2023, but only if the EU allocated appropriate donor funds (Financial support..., 2023).

Notably, the payment of a special budget subsidy for cattle (cows) under the budget programme “Support to farms and other agricultural producers” pursued social rather than economic goals. Its task was to support small agricultural producers in the difficult conditions of martial law, when agricultural logistics were severely disrupted, and households did not understand what to do with their existing cows. The purpose of the special budget subsidy for cattle (cows) was to “calm down” the market and provide targeted support to the most vulnerable category of agricultural producers who were deprived of the opportunity to attract financial resources from other sources to ensure the continuation of agricultural activities (Special budget subsidy..., 2022).

The introduction of this area of budget support was not directly related to the development of dairy farming, as the purpose was to provide prompt support to small agricultural producers. The latter's activities are crucial for achieving an adequate level of food security, particularly in terms of milk and dairy products. The value of such support lies in its promptness and targeting, but it should be considered as a one-off rather than a systemic measure. Most likely, this practice will not be applied to agricultural producers in Ukraine in the future.

► Discussion

Thus, in the evolutionary development, Ukraine has devised its own instruments of state financial support for the development of dairy farming, which had many differences from those used in the EU countries. Although this toolkit was quite extensive, due to the low level of budget allocations, it did not have a substantial impact on the development of the dairy sector in Ukraine. Due to limited budgetary resources, there is a tendency to use selective rather than continuous budget support programmes. As a result, most dairy businesses in Ukraine have found budget support resources unavailable. Furthermore, due to insufficient budgetary allocations for state financial support for dairy farming, the principle of proportionality was applied when distributing the amounts, which made it unpredictable.

Insufficient attention was paid to stimulating the development of small dairy producers when formulating the policy of state support for the development of dairy farming. In this context, the efficiency of small dairy farms depended more on the level of entrepreneurial skills of such business entities than on the prevailing conditions for running a dairy business. This feature is highlighted in the study by A. Jedik *et al.* (2014).

The importance of dairy farming in ensuring food security (both global and regional, as well as in individual countries) determines the need for a rational combination of market self-regulation and state regulation. These issues are constantly being discussed by European scholars. G. Koutouzidou *et al.* (2022) focus on the issue of the efficiency of the use of available resources by dairy farms. The authors present the main structural and financial characteristics of dairy farms with different efficiency, which resulted in the formation of the appropriate farm structure and the identification of the main cost factors. The authors state that dairy farms must constantly ensure their economic sustainability and be less risk-averse in an environment where opportunities to reduce production costs on high-intensity farms are significantly reduced.

D. Läßle & G. Sirr (2019) note that the abolition of the milk quota has led to substantial changes in the EU dairy sector. They note considerable differences in the changes in milk production in individual EU countries after the implementation of the relevant EU decision. Using the example of Irish and Dutch dairy farms, they conduct a comparative analysis of the efficiency of their operation in terms of intensification and increase in production volumes – considering the average size of dairy farms, the amount of direct budget payments and investments made. J. Marzec & A. Pisulewski (2017) analysed the impact of EU Common Agricultural Policy (CAP) subsidies on the technical efficiency of Polish dairy farms. They identified several types of subsidies and assessed which ones were most probable to lead to substantial differences in the technical efficiency of dairy farms. The authors conclude that the impact of subsidies on the technical efficiency of dairy farms is negative.

M.-L. Augère-Granier (2018) notes that the dairy sector is the second largest agricultural sector in the EU. In this context, dairy policy is an integral component of the CAP and consists of several instruments designed to support farmers' incomes and address market imbalances. It includes the organisation of a common market, state intervention measures (purchase, storage, etc.), direct budgetary payments, and rural development measures. Therewith, the EU dairy policy is being dynamically updated, and updated state support packages are being developed and implemented.

M. Gaworski *et al.* (2016) note that there are currently substantial differences in the levels of development of the dairy sector in individual EU countries. Specifically, they point out that further transformation of the Polish dairy sector requires overcoming the existing barriers that hinder its effective development, namely, the prominent level of dispersion in the production of raw milk and its low technological level. In view of this, they see further areas for the transformation of the Polish dairy sector in terms of technical and technological re-equipment and increasing the profitability of dairy farms, which requires the implementation of state support measures.

It is difficult to disagree with the conclusions of G. Koutouzidou *et al.* (2022) that dairy farms need to always ensure their economic sustainability – despite the state financial support, which is not stable in Ukraine. In this context, the conclusions of M. Klopčič *et al.* (2019) are quite accurate that instability in the choice of further

development strategy by dairy farms due to changes in state financial support policy makes future decision-making insufficiently effective. Accordingly, when approving development strategies, dairy business entities should consider the results of market forecasting rather than the possibility of using state financial support resources in their activities.

The conclusions of D. Läßle & G. Sirr (2019), A. Groeneveld *et al.* (2016) that changes in the state policy on dairy farming have led to an increase in the level of intensification of dairy farming and, accordingly, its concentration. L. Čechura *et al.* (2021) analysed the impact of the abolition of milk quotas in the EU. There is heterogeneity in milk production across EU member states and increasing returns to scale. The abolition of quotas prompted farms to optimise their size. G. Trnkova *et al.* (2012) investigated the impact of subsidies on livestock enterprises in the Czech Republic. Subsidies reduced economic performance and increased costs for enterprises that received them compared to those that did not.

The conclusions of A. Pisulewski & J. Marzec (2022) that the possibility of obtaining budget financing for investment projects in the dairy farming sector is a factor that determines their implementation and that the investments made have led to an improvement in the economic situation of dairy farms due to a substantial increase in their income.

In Ukraine, since the early 2020s, dairy businesses have been effectively deprived of significant amounts of state financial support. After the abolition of a fairly effective support mechanism in the form of a special VAT regime, the state has been unable to offer an adequate replacement. On the other hand, the development of Ukraine's dairy sector was hindered by external factors – the effects of the spread of COVID-19 (in 2020) and Russian military aggression in 2022 – which led to lower prices for crop products and a decline in the profitability of traditionally high-margin export-oriented crop production.

In 2022, Russian armed aggression limited the state's ability to provide budgetary support for the development of agricultural production in general and dairy farming in particular. Therewith, Ukraine is currently undergoing substantial structural changes in the dairy farming sector, with a considerable reduction in the number of small milk producers and a process of dairy farm concentration. In this context, there is a need to revise the existing instruments of financial incentives for the development of dairy farming to ensure that they are in line with the processes currently taking place in the dairy farming sector.

► Conclusions

Ukraine's dairy sector is undergoing substantial structural changes: the role of private households, which was key in the mid-2010s, is rapidly declining; the number of small

dairy farms is decreasing; and the concentration of cows is actively taking place. In 2023, the average number of cows in agricultural enterprises that keep them will approach 300 cows (in 2015, it was one and a half times lower). Due to the rapid decline in milk production by households (expected to be only about half of the figure for the first half of the 2010s in 2023), there is an urgent need to replace it – at least in terms of supply to industrial processing – with production on highly industrialised dairy farms. This requires the implementation of a suitable state incentive policy, primarily through tax and budgetary instruments.

Ukraine has developed certain tools for budgetary support for the development of dairy farming, which has several differences from the practice of providing budgetary subsidies in the EU. As the level of budget allocations under this instrument was too low (less than 0.5% of the value of the sector's gross output), it did not have a substantial impact on the development of the dairy sector in Ukraine. The Ukrainian model of dairy development envisages further consolidation of dairy farms. This vector of development is determined by the need to meet the existing raw material needs of dairy processing and ensure the competitiveness of Ukrainian dairy products in the internal and external markets. It is necessary to create conditions for investment and loans for agricultural businesses, expand the land bank for fodder crops and farms, and introduce financial measures to support the development of dairy farming, including tax and budgetary instruments.

The scientific originality of the findings of this study lies in a comprehensive summary of the state of development of dairy farming in Ukraine with the identification of key trends, assessment of the effectiveness of the instruments used to support it through the levers of tax and budget policy and proposals for its further improvement. Areas for future research in this area should include the following issues: formation of an effective instrument of state financial support for the development of the dairy farming sector in Ukraine in the context of limited budgetary resources; stimulation of international investors' involvement in the development of the sector in the post-war economic recovery of Ukraine; resumption of active use of tax incentives for activity in the sector; promotion of the formation of dairy clusters in the territories most affected by Russian military operations.

► Acknowledgements

The authors of this study would like to express their sincere gratitude to the Armed Forces of Ukraine and business entities operating in the dairy farming sector.

► Conflict of Interest

The authors of this study declare no conflict of interest.

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Тенденції розвитку молочного скотарства та його державної фінансової підтримки в Україні

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► **Анотація.** Значимість молочного скотарства для забезпечення продовольчої безпеки та формування доданої вартості, створюваної у сільському господарстві, зумовлює необхідність раціонального поєднання механізмів ринкового саморегулювання із інструментами державного втручання в економічні процеси в галузі. Метою дослідження була оцінка розвитку молочного скотарства в Україні та визначення способів поліпшення його державної підтримки. В ході роботи використовувалися наступні методи науково пізнання: аналізу та синтезу, індукції та дедукції, абстрактно-логічний, історичний, порівняльного аналізу, монографічний, розрахунково-конструктивний, графічний, табличний, статистичного аналізу, узагальнення, причинно-наслідкового та ретроспективного аналізу, аналітичного вирівнювання рядів динаміки, економічного моделювання та прогнозування. За результатами використання зазначених методів узагальнено сучасні тенденції розвитку молочного скотарства в Україні та його державної фінансової підтримки шляхом застосування інструментів податково-бюджетного регулювання. Розкрито специфіку наявної структури молочного скотарства в Україні, яка, на відміну від країн Європейського Союзу, представлена трьома категоріями господарюючих суб'єктів. Встановлено, що з початку 2010-х рр. в Україні відбуваються процеси концентрації діяльності у сфері молочного скотарства. Виявлено пряму залежність між величиною утримуваного поголів'я корів та рентабельністю діяльності у сфері молочного скотарства. Визначено, що підприємства, які утримують до 100 корів, поступово зменшують обсяги діяльності у секторі молочного скотарства з огляду на її нерентабельність. Здійснено оцінку змін у структурі молочних ферм в європейських країнах із середини 1990-х рр. до початку 2020-х рр. та встановлено, що їм також притаманні тенденції щодо концентрації молочного скотарства. Здійснено оцінку ефективності державної фінансової підтримки розвитку молочного скотарства в Україні за рахунок інструментів податково-бюджетного регулювання у довоєнний період та в режимі воєнного стану. Охарактеризовано переваги та недоліки застосовуваних інструментів бюджетної підтримки молочного скотарства, обґрунтовано пропозиції щодо застосування інструментарію податково-бюджетного стимулювання розвитку молочного скотарства у період повоєнного відновлення економіки України з урахуванням наявних тенденцій розвитку молочного скотарства в Україні. Практична значимість дослідження полягає у можливості використання одержаних результатів при формуванні програмних документів щодо повоєнного розвитку агропромислового комплексу України в цілому та, зокрема, його молокопродуктового підкомплексу

► **Ключові слова:** молочний сектор; державне регулювання; структура молочних ферм; податково-бюджетна політика; програми бюджетної підтримки; категорії виробників молока



UDC 336:648

Regional aspect of the efficiency of lending to the agricultural sector of the Ukrainian economy

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► **Abstract.** Ukrainian agriculture has shown resilience, adaptability, and production flexibility during the war. At the same time, the priority issues are the lack of financial resources for business operations, the restoration of damaged facilities and ensuring technological discipline. In this context, the issue of lending to agricultural enterprises is of great relevance. The purpose of this study was to improve and develop methodological tools for assessing the credit burden and efficiency of lending in agriculture by region of Ukraine. The study employed several methods of cognition: comparative analysis, tabular, graphical, statistical, computational-constructive, abstract-logical. In 2015-2022, lending to agricultural producers increased by 2.4 times (by 43.5% or UAH 35.9 billion in 2022 alone). The share of loans attracted is dominated by Kyiv Oblast (31%). The share of lending to the agricultural sector increased by 2.6 times (from 6.1% to 15.7%). Ukrainian agrarians are lent mainly in the national currency (76.4% of disbursed loans) and for terms up to one year (54.4%), with terms of 1 to 5 years (41.2%). In 2015-2021, the loan burden per business entity and per employee almost doubled. The highest lending efficiency was demonstrated by farms in Zakarpattia, Zhytomyr, Rivne, Luhansk, and Chernivtsi oblasts. During the first year of the full-scale war, the efficiency of lending in agriculture fell by 48% (from 8.63 to 4.49 thousand UAH). Agricultural enterprises need support from both the state and credit institutions. The practical significance of this study is determined by the improvement of tools for measuring the level of credit burden and assessing the effectiveness of lending in the agricultural sector of the economy by regions of Ukraine, which can be used by public and sectoral authorities in the regional practice of monitoring and intensifying the practice of state financial support for rural producers

► **Keywords:** credit burden indicator; efficiency indicator; state support; agriculture

► Introduction

Lending to business entities in the agricultural sector of Ukraine has been one of the determining factors not only for their efficient operation and sustainable development, but also for the survival and preservation of their production and resource potential. With the outbreak of a full-scale war, the problem of a shortage of working capital required to purchase plant and animal protection products,

seeds, fertilisers, and fuel has become catastrophically acute. The restoration of destroyed and damaged industrial buildings, facilities and equipment is still an extremely challenging task. According to surveys, since the beginning of the war, about a quarter of agricultural producers have lost access to finance altogether, and another 20% report significant difficulties in obtaining funds (Restoration

► **Suggested Citation:** Cheremisina, S., & Tomashuk, I. (2023). Regional aspect of the efficiency of lending to the agricultural sector of the Ukrainian economy. *Ekonomika APK*, 30(5), 46-58. doi: 10.32317/2221-1055.202305046.

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of agricultural production..., 2023). Expanding real opportunities for access to finance and to cheap credit is a priority for rural producers and the state and a key to a speedy post-war economic recovery. Consequently, a comprehensive retrospective assessment of the comparative efficiency of lending to the agricultural sector of the economy is becoming increasingly important.

Among Ukrainian scholars, the following have made a significant contribution to the investigation of modern problems of agricultural lending: Yu.O. Lupenko & S.V. Andros (2019) identified the main factors of demand for credit resources from agricultural enterprises, measured the impact of bank loans on the development of the agricultural sector of the economy, considered the main obstacles to lending by financial institutions to Ukrainian farmers, and proposed effective solutions to eliminate these obstacles. O.A. Sergienko & A.S. Gula (2018) assessed the efficiency of lending to the agro-industrial complex from a regional perspective. The authors have developed and tested a methodological approach to assessing and analysing the levels of performance and lending of agro-industrial complex (AIC) entities, based on the results of using cluster analysis methods and a spatial multi-element matrix of correspondence of the components under study (level of performance of AIC and lending volumes). O. Chygryn & O. Ivakhnenko (2020) investigated the main problems faced by participants in the bank lending market in the agricultural sector. The authors examine the main obstacles to lending to agricultural enterprises by banking institutions, the main risks of banking institutions themselves, and measure the relationship between the profitability of agricultural enterprises and interest rates on bank loans in terms of their impact on the further development of the business entity and the agrarian economy as a whole.

S. Arzhevitin *et al.* (2021) identified, measured, and analysed the main factors that constrain lending to Ukrainian agricultural enterprises, and substantiated effective solutions to improve the agricultural lending system. L. Avramchuk & N. Desyatnik (2021) emphasised the need to strengthen the role of the state in making clear decisions aimed at creating favourable conditions for access to credit resources for agricultural producers of all sectors of the agricultural economy. A. Bilochenko (2023) focused on the problems of credit provision of Ukrainian agricultural enterprises with credit resources under martial law. The author examined the dynamics of bank lending after the outbreak of war and outlined the real prospects for its expansion in the post-war economic recovery.

M. Nehrey & O. Trofimtseva (2022) thoroughly investigated the problems of the functioning of the agricultural sector of Ukraine in the context of war and substantiated the need for its support from both the state and foreign funds, organisations, and states. Particular emphasis was placed on expanding state support for the agricultural sector in the financial sector by providing access to cheap loans and launching new grant programmes. O. Shpanel-Yukhta (2022) summarised the specific features of bank lending in Ukraine in the context of Russia's large-scale military aggression and found that, despite the martial law, bank lending to certain market segments grew (specifically, lending to agriculture, the introduction of credit support programmes for business during the war).

Among the world researchers, the following authors have made a significant contribution to the study of the problems of bank lending to the agricultural sector of the economy. C.A. Ngong *et al.* (2022) conducted an in-depth study of the impact of bank credit on agricultural productivity in the Economic and Monetary Community of Central Africa (CEMAC) from 1990 to 2019. The authors conclude that CEMAC governments should encourage efficient ways to increase the flow of bank credit to private agricultural enterprises through effective bank intermediation.

M. Rizwan *et al.* (2019) conducted a comprehensive study of the state, efficiency, current problems, and practical solutions to improve the efficiency of lending to rural producers in Pakistan. Proceeding from the study's findings, the authors propose that the government and other stakeholders review agricultural lending policies and simplify procedures for granting loans to farmers. A. Khanal & O. Omobitan (2020) investigated the factors influencing credit constraints and measured their impact on farm productivity (Tennessee, USA). The authors emphasise that improving the capacity and methods of agricultural lending in rural institutions can improve access to credit and increase the financial efficiency of small farmers.

At the same time, the research is aimed at identifying mechanisms and measuring the impact of bank lending on economic performance and opportunities for further development of rural producers. Considering this, the existing developments require structural systematisation, additional methodological substantiation, and practical adaptation to the extremely difficult business conditions faced by Ukrainian farmers during a full-scale war. The purpose of this study was to retrospectively measure the efficiency of lending to Ukrainian agriculture, considering regional differentiation.

To fulfil the purpose set, the tasks of the study were defined as follows:

- ▶ to compare the regional dynamics of lending to agricultural producers before and during the full-scale war;
- ▶ to substantiate the calculation tools and determine the dynamics of the credit burden and efficiency of lending in agriculture by regions of Ukraine;
- ▶ to make a comparative assessment of the dynamics of the efficiency of lending to agriculture and the entire non-financial sector of Ukraine's economy.

▶ Materials and Methods

The study employed the following methods: comparative analysis – to compare the dynamics of lending to agricultural producers in the regional aspect with the relevant indicators on average in Ukraine; tabular – to visualise the findings of the study; and graphical – to illustrate the current dynamics and comparative characteristics of lending efficiency. The statistical method was used to find the dynamics of credit burden indicators in agriculture. The computational-constructive method was used to analyse and compare the dynamics of indicators of efficiency of lending to agriculture in Ukraine in general and in the regional aspect. The abstract-logical method was used to formulate conclusions.

The study also used the following information base of the State Statistics Service (dynamics of production and

sales of agricultural products, number of business entities, number of employees) (Official website of the State..., n.d.); information and analytical data of the monetary statistics of the National Bank of Ukraine (NBU) (loans granted to agricultural entities, regional breakdown of lending to the agricultural sector of the economy, interest rates on loans granted) (Financial Sector Statistics, n.d.); operational data of the Ministry of Agrarian Policy and Food of Ukraine on the state of state support for farmers and the implementation of the "Affordable Loans 5-7-9%" programme (Strategy of the Ukraine's..., 2023).

The indicator of the share of lending to agriculture in the total volume of lending to sectors of the Ukrainian economy was calculated according to the following formula:

$$IL_{ij} = \frac{Lag_{ij}}{Ltotal_{ij}} \times 100\%, \quad (1)$$

where IL_{ij} is the share of lending to the agricultural sector of the i^{th} region in the j^{th} period, %; Lag_{ij} is the amount of loans granted to rural commodity producers of the i^{th} region in the j^{th} period, UAH million; $Ltotal_{ij}$ is the total amount of loans issued to business entities of the non-financial sector of the economy of the i^{th} region in the j^{th} period, UAH million.

The loan burden indicator in agriculture (per 1 enterprise) is calculated using the following formula:

$$LW_{enij} = \frac{Lag_{ij}}{NEn_{ij}}, \quad (2)$$

where LW_{enij} is the credit load of the i^{th} region in the j^{th} period, thousand UAH per 1 enterprise; NEn_{ij} is the number of economic entities in agriculture of the i^{th} region in the j^{th} period, units.

The indicator of the credit burden in agriculture (per 1 employed person) is calculated using the following formula:

$$LW_{emij} = \frac{Lag_{ij}}{NEm_{ij}}, \quad (3)$$

where LW_{emij} is the credit load of the i^{th} region in the j^{th} period, thousand UAH per 1 employed worker; NEm_{ij} is the number of employed workers in agriculture of the i^{th} region in the j^{th} period, persons.

Lending efficiency (in terms of agricultural output) is calculated using the following formula:

$$EPL_{ij} = \frac{AgP_{ij}}{Lag_{ij}}, \quad (4)$$

where EPL_{ij} is the efficiency of agricultural lending in the i^{th} region in the j^{th} period, produced agricultural products per 1000 borrowed loans; AgP_{ij} is the volume of production of agricultural products of the i^{th} region in the j^{th} period, thousand UAH.

Lending efficiency (by agricultural products sold) is calculated using the following formula:

$$ESL_{ij} = \frac{SP_{ij}}{Lag_{ij}}, \quad (5)$$

where ESL_{ij} is the efficiency of agricultural lending in the i^{th} region in the j^{th} period, realised agricultural products per 1000 borrowed loans; SP_{ij} – volume of sold agricultural products of the i^{th} region in the j^{th} period, thousand UAH.

The efficiency of lending to the non-financial sector of Ukraine's economy and its regions is calculated using the following formula:

$$EEC_{ij} = \frac{GRP_{ij}}{Ltotal_{ij}}, \quad (6)$$

where EEC_{ij} is the efficiency of lending to the economy of the i^{th} region in the j^{th} period, produced gross regional product per 1000 borrowed loans; GRP_{ij} is the production volume of the gross regional product of the i^{th} region in the j^{th} period, thousand UAH.

► Results and Discussion

A comprehensive analysis of the overall and regional dynamics of lending to agricultural entities revealed a steady upward trend. In 2015-2022, the total volume of loans to agricultural producers increased 2.4 times, from UAH 48.4 billion to UAH 118.5 billion (Table 1). Kyiv Oblast is the leader in terms of loans attracted, accounting for 31% (or UAH 36.6 billion) of the total volume of loans to the Ukrainian agricultural economy. Kharkiv (7.3%), Dnipro (6.9%), Odesa (6.1%), Lviv (5.1%), Vinnytsia (4.5%) and Kirovohrad (4.4%) oblasts are the next largest lending regions for agricultural producers. Zhytomyr, Chernihiv, Sumy, Kirovohrad, Luhansk, and Zaporizhzhia oblasts are leading in terms of loan growth. During the analysed period, the total volume of loans granted to agricultural producers increased by 16.4, 13.1, 9.1, 8.0, 7.0, and 6.9 times, respectively.

Table 1. Regional dynamics of lending to agricultural producers, (end-of-period balances), 2015-2022, UAH million

Oblast	2015	2016	2017	2018	2019	2020	2021	2022	2022-2015, %
Ukraine	48 425	55 374	59 706	67 675	61 600	61 486	82 600	118 504	241.2
Vinnytsia	815	719	903	1251	1659	1937	2647	5273	606.7
Volyn	345	436	673	781	925	785	911	2212	550.4
Dnipropetrovsk	4223	6256	6971	8211	8139	5120	6130	8129	207.3
Donetsk	336	294	100	238	459	345	868	600	218.8
Zhytomyr	103	149	359	501	503	524	860	1786	1 640.8
Zakarpattia	73	73	118	147	155	104	168	249	354.8
Zaporizhzhia	635	1063	1597	1837	2185	2387	3753	4289	690.4
Ivano-Frankivsk	224	272	202	506	438	515	795	1163	474.6
Kyiv	26 178	27 532	30 063	27 941	18 416	19 870	25 232	36 614	120.5
Kirovohrad	594	1114	1372	1751	1858	2100	2474	5218	797.6

Table 1, Continued

Oblast	2015	2016	2017	2018	2019	2020	2021	2022	2022-2015, %
Luhansk	73	94	114	176	265	260	516	480	700.0
Lviv	2439	2864	1468	2291	2544	2965	4264	6019	241.8
Mykolaiv	2103	2253	1028	1457	1754	1738	2336	3344	158.8
Odesa	2074	1708	2240	3598	3895	4702	4421	7301	362.7
Poltava	2075	1783	1692	2079	2321	1776	2651	4595	219.2
Rivne	340	392	429	676	683	740	539	1085	345.9
Sumy	330	652	1017	1416	1441	1413	2303	2814	914.2
Ternopil	627	1080	1166	1469	1740	1708	2760	4699	676.9
Kharkiv	1911	2944	4019	5464	5625	6066	9315	8687	545.3
Kherson	405	551	670	1185	1250	1197	1838	1753	485.9
Khmelnyskyi	1257	1285	1145	1559	1570	1829	2980	4834	325.1
Cherkasy	870	947	1305	1610	2232	1824	2471	3388	407.7
Chernivtsi	163	298	185	230	227	261	369	604	398.2
Chernihiv	233	616	870	1301	1315	1320	2001	3369	1 308.2

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: compiled by the authors of this study based on Financial Sector Statistics (n.d.)

A noticeable increase in the share of lending to agriculture in the total volume of lending to sectors of the Ukrainian economy has been identified. Thus, in 2015-2022, the all-Ukrainian share of agricultural loans in the

volume of lending to the non-financial sector increased from 6.1% to 15.7% (Fig. 1).

This positive trend is typical for all regions of Ukraine (Vernihorova, 2021).

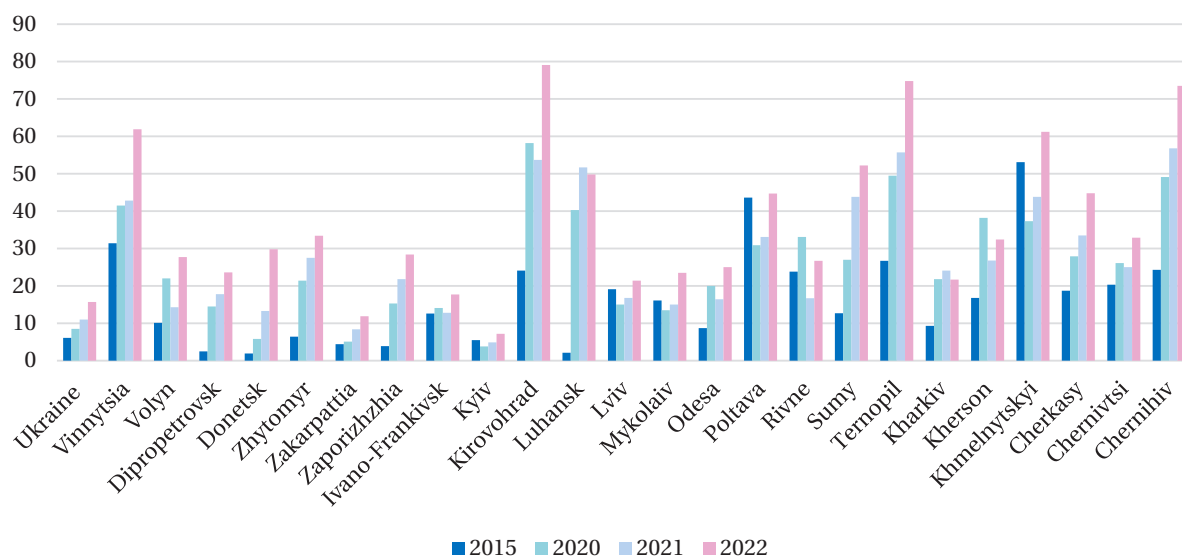


Figure 1. Regional dynamics of the share of lending to agriculture in the total volume of lending to sectors of the Ukrainian economy, %

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: compiled by the authors of this study based on Financial Sector Statistics (n.d.)

The largest share of agricultural loans in the regional economy was recorded in Kirovohrad (79.1%), Ternopil (74.8%), Chernihiv (73.5%), Volyn (61.9%), Khmelnytskyi (61.2%), and Sumy (55.2%) oblasts. A retrospective structural analysis of agricultural loans revealed the following.

Ukrainian farmers receive loans mainly in the national currency. In 2015-2022, the share of hryvnia-denominated loans increased from 59.1% to 76.4%. Accordingly, the share of foreign currency loans decreased from 40.9% to 23.6% over this period (Table 2).

Table 2. Structure of loans granted to agricultural producers, 2015-2022, %

Year	Total	Including by timeframe			including							
					in national currency				in foreign currency			
		up to 1 year	1-5 years	over 5 years	total	Including by timeframe			total	Including by timeframe		
						up to 1 year	1-5 years	over 5 years		up to 1 year	1-5 years	over 5 years
2015	100.0	45.6	42.0	12.4	59.1	21.5	27.3	10.3	40.9	24.1	14.8	2.1
2016	100.0	44.2	35.7	20.1	68.9	23.9	26.7	18.3	31.1	20.3	9.1	1.7
2017	100.0	30.2	38.5	31.4	77.0	20.2	28.8	27.9	23.0	9.9	9.6	3.4
2018	100.0	36.3	44.7	19.0	73.8	23.2	34.5	16.1	26.2	13.1	10.2	2.9
2019	100.0	43.3	50.7	5.9	71.2	26.8	40.7	3.7	28.8	16.6	10.0	2.2
2020	100.0	48.9	46.6	4.5	70.1	35.6	32.2	2.3	29.9	13.3	14.4	2.2
2021	100.0	45.1	49.6	5.3	71.6	30.8	38.1	2.7	28.4	14.4	11.5	2.6
2022	100.0	54.4	41.2	4.3	76.4	41.5	32.8	2.1	23.6	13.0	8.4	2.2
2022-2015, +/- %	–	8.9	-0.8	-8.1	17.3	20.0	5.5	-8.2	-17.3	-11.1	-6.3	0.1

Source: compiled by the authors of this study based on Financial Sector Statistics (n.d.)

In terms of term structure, as of the end of 2022, the share of short-term loans increased from 45.6% to 54.4%, and their volume increased from UAH 22.1 billion in 2015 to UAH 64.5 billion in 2022. Medium-term loans with a maturity of 1 to 5 years accounted for 41.2%. The share of long-term loans with a maturity of 5 years or more decreased from 12.4% to 4.3% (from UAH 6 billion to UAH 5.1 billion) during the analysed period.

The average cost of loans to agricultural businesses, according to the statistical reporting of Ukrainian banks, was 16.7% per annum in national currency at the end of 2022, and 5% in foreign currency. Therewith, the cost of short-term hryvnia loans differed from long-term loans by only 0.8%. Short-term loans in foreign currency were much cheaper – 3.1% compared to 5.4% per annum (Table 3).

Table 3. Average cost of loans to agricultural entities, 2015-2022, %, in UAH

Period	in national currency			in foreign currency		
	total	short-term	long-term	total	short-term	long-term
2015						
at the beginning of the year	16.4	16	22.2	8.5	8.3	13.2
at the end of the year	20.7	20.7	20	7.9	8.2	3.7
changes during the year	4.3	4.7	-2.2	-0.6	-0.1	-9.5
2016						
at the beginning of the year	19.8	19.5	25.6	8.2	8.2	8
at the end of the year	17.4	16.8	21.1	7.1	6.6	9.9
changes during the year	-2.4	-2.7	-4.5	-1.1	-1.6	1.9
2017						
at the beginning of the year	14.5	14.1	21.9	6.9	6.8	7.1
at the end of the year	16.1	16	17.8	5.9	5.6	6.7
changes during the year	1.6	1.9	-4.1	-1	-1.2	-0.4
2018						
at the beginning of the year	14.9	14.5	22.1	6.4	6.2	7.8
at the end of the year	20	19.7	20.5	5.3	4.5	7.4
changes during the year	5.1	5.2	-1.6	-1.1	-1.7	-0.4
2019						
at the beginning of the year	20.5	20.6	20	4.3	4.2	7.3
at the end of the year	15.2	13.9	19.2	4.4	6.9	3.9
changes during the year	-5.3	-6.7	-0.8	0.1	2.7	-3.4
2020						
at the beginning of the year	13.6	13.4	20.6	3.6	3.5	7

Table 3, Continued

Period	in national currency			in foreign currency		
	total	short-term	long-term	total	short-term	long-term
at the end of the year	9.3	8.9	12.5	4.6	4.7	4.1
changes during the year	-4.3	-4.5	-8.1	1	1.2	-2.9
2021						
at the beginning of the year	7.8	7.5	15.1	3.6	3.5	6.9
at the end of the year	10.2	9.5	12	2.6	2.5	6
changes during the year	2.4	2	-3.1	-1	-1	-0.9
2022						
at the beginning of the year	10.2	9.8	15.4	5.1	4.8	6.0
at the end of the year	16.7	16.0	16.8	5.0	3.1	5.4
changes during the year	+4.5	+6.2	+1.4	-0.1	-1.7	-0.6
2023						
at the beginning of the year	16.9	16.2	17.1	5.6	3.7	6.0
by 1.07	19.3	18.0	19.4	6.4	4.0	6.5

Source: compiled by the authors of this study based on Financial Sector Statistics (n.d.)

During the first year of the war, the cost of loans to agricultural producers in national currency increased by 1.6 times – from 10.2% at the beginning to 16.7% at the end of the year. The average cost of loans in foreign currency stayed almost unchanged, while short-term lending fell by 1.7% p.a., from 4.8% at the beginning of the year to 3.1% at the end of the year. Local currency loans continue to rise in price. In the first half of 2023, the average cost of such loans increased by 2.6%, from 16.7% to 19.3%. The interest rate on short-term loans increased from 16% to 18%, and on long-term loans – from 16.8% to 19.4%. Given the disappointing inflation forecasts of the National Bank of Ukraine, this trend will continue and the interest rate on hryvnia loans will increase (Shyian *et al.*, 2020).

A retrospective analysis of the dynamics of the credit burden of the agricultural sector of Ukraine's economy revealed the following destructive changes. The total loan burden per business entity in agriculture increased by 1.9 times in 2015-2021, from UAH 684.7 thousand to UAH 1 271.6 thousand. In the regional context, the highest growth rates were observed in the farms of Zhytomyr, Chernihiv, Zaporizhzhia, Sumy, Luhansk, Kharkiv, and

Ternopil oblasts – by 8.5, 8.5, 7.3, 6.7, 6.0, 5.5, and 5.5 times, respectively (Table 4). The leaders in terms of the absolute loan burden per agricultural enterprise as of the beginning of 2022 are Kyiv (UAH 7970 thousand), Kharkiv (UAH 2617 thousand), Lviv (UAH 2260 thousand), Ternopil (UAH 1772 thousand), Sumy (UAH 1330 thousand), and Khmelnytskyi (UAH 1329 thousand) regions. While the average Ukrainian credit load indicator is UAH 1272 thousand per business entity, Kyiv region enterprises are almost 6.3 times higher. The lowest levels of loan burden are in Zakarpattia (UAH 114.2 thousand), Chernivtsi (UAH 301 thousand), Luhansk (UAH 326 thousand), Donetsk (UAH 472 thousand), and Mykolaiv (UAH 491 thousand) oblasts. On average in Ukraine, the loan burden per person employed in agriculture stood at UAH 143.4 thousand at the beginning of 2022, almost double the level of 2015. Similarly, to the previous indicator, the leaders in terms of loans per employee are Kyiv, Kharkiv, and Lviv oblasts – UAH 600.1, UAH 296.1, and UAH 186.6 thousand, respectively. The lowest figures (up to UAH 50 thousand per employee) were recorded in Zakarpattia, Zhytomyr, Luhansk, Rivne, and Chernivtsi oblasts.

Table 4. Dynamics of the loan burden in agriculture, 2015-2021, UAH thousand

	2015		2017		2019		2021		2021 in % to 2015	
	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee
Ukraine	684.7	75.4	858.6	93.9	897.0	101.0	1271.6	143.4	185.7	190.3
Vinnitsia	190.2	17.3	225.9	21.9	422.4	40.9	696.6	69.9	366.3	405.1
Volyn	244.2	25.2	536.7	51.3	773.4	75.9	795.6	79.9	325.9	317.2
Dnipropetrovsk	651.0	105.4	1136.6	193.6	1346.4	249.3	1045.7	186.6	160.6	177.0
Donetsk	170.2	16.8	49.4	5.3	229.8	24.7	471.5	48.5	277.0	288.4
Zhytomyr	62.0	4.5	229.1	15.0	303.9	21.2	528.9	38.8	852.4	856.7
Zakarpattia	56.9	9.7	49.9	13.8	75.9	19.0	114.2	23.9	200.9	247.4
Zaporizhzhia	135.0	20.9	381.5	56.3	548.4	84.1	990.2	147.1	733.2	703.4

Table 4, Continued

	2015		2017		2019		2021		2021 in % to 2015	
	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee	per 1 business entity	per 1 employee
Ivano-Frankivsk	200.9	21.0	193.9	16.2	406.3	38.3	843.9	87.9	420.1	419.5
Kyiv	8008.0	549.5	9132.1	655.4	5466.3	409.1	7969.7	600.1	99.5	109.2
Kirovohrad	134.4	19.2	312.2	42.6	419.7	59.4	575.8	80.7	428.5	420.9
Luhansk	54.4	5.8	77.9	8.7	171.1	20.0	326.2	40.6	600.1	697.0
Lviv	1203.8	162.4	798.7	103.1	1404.0	164.5	2259.7	290.1	187.7	178.6
Mykolaiv	419.1	84.1	201.2	40.3	354.7	74.4	491.1	103.2	117.2	122.7
Odesa	344.1	61.7	355.3	64.1	684.3	125.2	1017.7	168.9	295.8	273.5
Poltava	542.9	41.1	445.7	34.1	590.7	53.6	670.0	65.4	123.4	159.4
Rivne	318.4	24.7	470.4	30.3	738.4	52.9	554.0	42.4	174.0	171.3
Sumy	197.7	13.0	630.9	38.8	848.1	57.1	1330.4	93.7	672.9	721.6
Ternopil	320.9	43.0	737.0	74.3	1132.8	109.0	1772.6	172.0	552.4	400.0
Kharkiv	473.0	54.8	1075.2	122.5	1528.9	176.0	2617.3	296.1	553.3	540.3
Kherson	111.1	16.2	186.4	26.2	362.7	53.9	576.0	80.8	518.3	497.6
Khmelnyskyi	531.7	45.3	505.1	42.3	687.4	60.5	1329.2	116.3	250.0	257.0
Cherkasy	288.6	22.0	426.7	33.1	704.1	60.7	813.6	72.7	282.0	330.8
Chernivtsi	111.3	16.5	132.2	20.3	170.2	28.1	301.2	49.9	270.7	302.0
Chernihiv	138.7	7.3	547.9	26.4	785.1	40.6	1181.2	63.9	851.7	880.0

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: authors' calculations based on Financial Sector Statistics (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Compared to the significant increase in the loan burden in agriculture, lending efficiency indicators were much more modest. Agricultural production per 1 thousand UAH of loans in Ukraine increased by 1.74 times in 2015-2021, from 4.95 to 8.63 thousand UAH (Table 5). However, a considerable increase in this indicator (from 3 to 1.5 times) was recorded only in Kyiv, Mykolaiv, Dnipro, Poltava, Rivne, and Lviv oblasts. The outsiders of the growth rate of lending efficiency are farms in Chernihiv Oblast, where agricultural production per unit of loans decreased by 60% – from UAH 42.6 thousand to UAH 17.0 thousand. In Sumy Oblast, the decrease was 59% (from UAH 29.8 to UAH 12.2 thousand), in Zhytomyr Oblast – 56.5% (from UAH 78.3 to UAH 34.0 thousand), in Zaporizhzhia Oblast – 52.6% (from UAH 15.8 to UAH 7.5 thousand), in Luhansk Oblast – 51.8% (from UAH 55.3 to UAH 26.4 thousand). In 2021, agricultural producers in Zakarpattia, Zhytomyr,

Rivne, Luhansk, and Chernivtsi oblasts demonstrated the highest lending efficiency (from UAH 25 to 47 thousand). Kyiv Oblast, as the absolute leader in terms of loan burden, was recognised as a complete outsider in terms of lending efficiency, with UAH 1.62 thousand of agricultural output per thousand of loans attracted. Admittedly, this is explained by the regional specific features of registration of many business entities and their legal affiliation with the city of Kyiv and Kyiv Oblast. The first year of the full-scale war had adverse consequences for the efficiency of lending to the agricultural sector. In Ukraine, agricultural production per UAH 1 thousand of borrowed loans almost halved compared to 2021 – from UAH 8.63 to UAH 4.51 thousand. The largest decrease in the efficiency index was recorded at 8.63 in the farms of Kherson (95%), Zaporizhzhia (82%), Luhansk (78%), Donetsk (62%), and Kirovohrad (59%) oblasts (Zakharchenko, 2017).

Table 5. Dynamics of lending efficiency indicators (agricultural production per thousand UAH of attracted loans), 2015-2022, thousand UAH

	2015	2016	2017	2018	2019	2020	2021	2022	2021 in % to 2015
Ukraine	4.95	4.60	4.17	3.98	11.05	9.96	8.63	4.51	174.4
Vinnitsia	22.36	29.65	22.62	18.06	34.46	25.14	22.47	9.22	100.5
Volyn	18.65	15.04	10.21	9.08	17.88	21.16	18.75	7.49	100.5
Dnipropetrovsk	3.59	2.43	2.19	1.91	5.22	7.11	7.26	4.43	202.5
Donetsk	20.65	25.55	76.81	29.23	44.14	56.23	24.14	9.24	116.9

Table 5, Continued

	2015	2016	2017	2018	2019	2020	2021	2022	2021 in % to 2015
Zhytomyr	78.28	63.13	27.71	22.21	54.40	49.76	34.02	13.68	43.5
Zakarpattia	56.11	54.31	34.08	29.26	57.15	82.23	46.76	31.72	83.3
Zaporizhzhia	15.84	9.34	6.01	4.47	12.42	10.05	7.51	1.65	47.4
Ivano-Frankivsk	25.43	21.31	29.85	12.07	30.37	26.73	18.27	12.25	71.8
Kyiv	0.54	0.56	0.50	0.66	2.22	1.72	1.62	0.88	298.8
Kirovohrad	18.52	10.81	7.56	7.14	19.37	12.09	15.01	6.16	81.1
Luhansk	55.28	51.24	39.71	28.10	54.52	49.24	26.64	8.52	48.2
Lviv	3.70	3.23	6.69	4.45	9.04	8.10	6.06	4.44	163.7
Mykolaiv	4.26	4.31	8.59	6.43	14.81	11.38	12.44	4.88	292.3
Odesa	5.13	6.96	5.27	3.32	7.26	3.67	7.49	3.11	145.9
Poltava	8.03	9.65	8.46	8.54	18.75	21.75	15.96	9.19	198.8
Rivne	18.85	17.15	16.45	10.71	24.53	23.32	32.65	15.53	173.2
Sumy	29.84	15.63	10.02	8.02	20.94	22.15	12.24	9.39	41.0
Ternopil	12.99	7.89	8.12	6.70	13.94	14.20	9.96	5.58	76.7
Kharkiv	7.68	5.32	3.51	2.74	6.84	6.22	3.98	1.88	51.8
Kherson	26.76	20.39	16.69	9.49	22.85	22.58	16.74	0.86	62.6
Khmelnyskyi	9.23	9.77	12.28	9.25	22.88	19.12	13.34	7.39	144.6
Cherkasy	16.81	15.82	10.16	10.11	18.04	17.38	17.31	11.02	103.0
Chernivtsi	26.30	14.38	24.39	20.65	45.15	39.18	30.27	16.99	115.1
Chernihiv	42.60	16.84	12.56	9.33	23.74	24.33	16.98	7.99	39.9

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: authors' calculations based on Financial Sector Statistics (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Determining and analysing the dynamics of the volume of agricultural products sold per unit of loans attracted, as another indicator of credit efficiency, revealed a more significant downward trend (Table 6). Thus, the average value of this indicator in Ukraine in 2015-2021 decreased by 3.8% (from UAH 7.0 to UAH 6.7 thousand). The largest (3-4 times) decrease in efficiency for this indicator was found in the farms of Chernihiv, Sumy, Zhytomyr, Luhansk, Zaporizhzhia, Kirovohrad, and Kharkiv oblasts. Only 5 oblasts of Ukraine showed an increase in the efficiency of lending in relation to the volume of agricultural products sold: Kyiv (by 174.3%), Mykolaiv (by 138.0%), Zakarpattia (by 128.2%), Lviv (by 124.0%), and Rivne

(by 121.0%). In 2021, agricultural producers in Luhansk Oblast demonstrated the highest value of the absolute lending efficiency indicator – UAH 19.79 thousand of sales per UAH 1 thousand of loans attracted, and the lowest value – in Kyiv region (UAH 2.35 thousand). According to the Official website of the State Statistics Service of Ukraine (n.d.), in 2022, the total volume of agricultural sales in Ukraine increased by 10% compared to 2021, from UAH 553 billion to UAH 633 billion. A comparison of this indicator with the available volumes of loans granted to rural producers in 2022 revealed a 21% decrease in lending efficiency, from UAH 6.69 thousand to UAH 5.31 thousand per 1 thousand loans.

Table 6. Dynamics of lending efficiency indicators (agricultural products sold per thousand UAH of loans attracted), 2015-2021, thousand UAH/thousand UAH

	2015	2016	2017	2018	2019	2020	2021	2021 in % to 2015
Ukraine	6.96	5.26	5.97	5.83	6.64	7.16	6.69	96.2
Vinnitsia	36.84	27.25	24.83	21.99	17.64	14.04	14.81	40.2
Volyn	16.67	11.67	9.85	10.05	8.07	10.82	12.06	72.4
Dnipropetrovsk	4.91	2.48	2.67	2.27	2.51	4.46	4.79	97.5
Donetsk	21.72	27.62	97.79	40.99	22.28	35.37	16.38	75.4
Zhytomyr	64.34	46.86	26.55	22.34	27.17	26.37	17.19	26.7
Zakarpattia	6.39	6.71	7.42	6.52	5.15	9.08	8.19	128.2
Zaporizhzhia	18.54	11.45	8.76	7.23	6.90	7.59	5.83	31.5

Table 6, Continued

	2015	2016	2017	2018	2019	2020	2021	2021 in % to 2015
Ivano-Frankivsk	19.67	14.08	27.51	11.86	14.33	14.23	8.64	43.9
Kyiv	1.35	1.18	1.42	1.86	2.77	2.43	2.35	174.3
Kirovohrad	32.02	13.43	11.05	10.29	11.36	9.91	10.97	34.3
Luhansk	66.65	62.04	59.58	39.60	28.27	37.23	19.79	29.7
Lviv	3.06	2.10	5.72	4.95	4.57	4.09	3.80	124.0
Mykolaiv	6.18	5.63	15.67	10.71	8.16	7.85	8.52	138.0
Odesa	6.22	8.67	8.02	5.61	4.01	2.44	5.11	82.1
Poltava	16.44	14.30	16.17	13.09	12.55	18.46	14.47	88.0
Rivne	15.31	11.04	12.08	10.16	9.71	8.94	18.53	121.0
Sumy	45.82	21.60	18.37	13.91	15.60	19.06	12.73	27.8
Ternopil	15.54	8.40	9.93	9.08	7.70	9.55	7.91	50.9
Kharkiv	9.47	6.12	6.13	3.74	3.91	4.70	3.31	35.0
Kherson	26.74	20.81	18.15	11.62	10.42	12.56	10.40	38.9
Khmelnyskyi	13.73	10.33	14.57	13.62	14.01	13.16	10.70	78.0
Cherkasy	28.60	19.86	15.83	15.11	11.68	14.53	13.72	48.0
Chernivtsi	13.94	5.75	11.63	10.19	9.60	13.17	8.07	57.9
Chernihiv	84.89	26.39	26.06	19.75	21.38	24.96	20.27	23.9

Note: data excludes the territories temporarily occupied by the Russian Federation and parts of the territories where military operations are (were) conducted

Source: authors' calculations based on Financial Sector Statistics (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Analogous calculations of the efficiency of lending to the non-financial sector of the economy, namely the dynamics of the ratio of gross regional product to total lending,

showed a positive growth rate of almost 3 times in 2015-2022. However, the absolute performance indicator in monetary terms was lower than in the agricultural sector (Fig. 2).

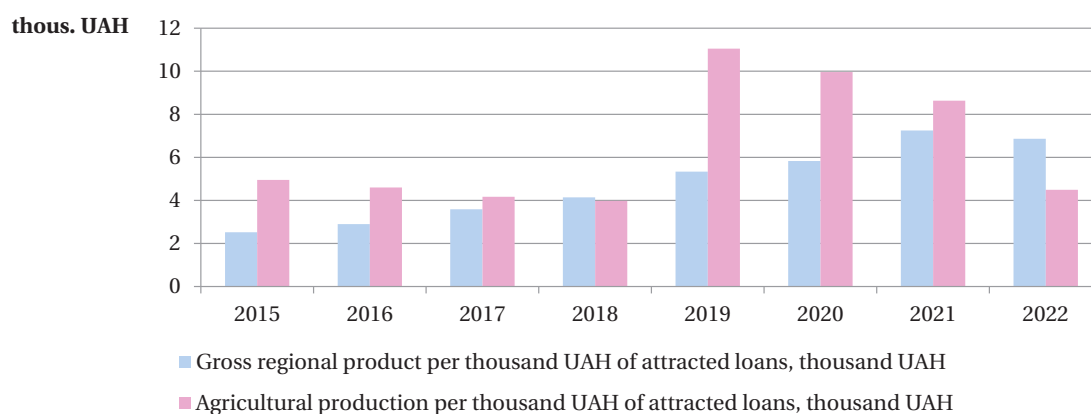


Figure 2. Comparative dynamics of the efficiency of lending to agriculture and the non-financial sector of Ukraine's economy, 2015-2022

Source: authors' calculations based on Financial Sector Statistics (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Thus, while in 2015, the efficiency of lending to the agricultural sector was twice as high as the overall economic indicator, in 2021 it was only 20% higher. In turn, 2022 considerably changed this trend. The efficiency of lending in agriculture fell by 48% (from UAH 8.63 to UAH 4.51 thousand) and was 30% lower than the overall economic indicator. However, during the war, state-owned and commercial banks continue to lend actively.

It aims to ensure that Ukrainian farmers are not only able to carry out their current activities, but also to restore and modernise their production facilities and adapt them to the new challenging environment. During the first year of the war, agricultural lending increased by 43.4% (or UAH 35.9 billion). Therewith, short-term lending increased by 73% (from UAH 37.3 billion to UAH 64.5 billion) (Fig. 3).

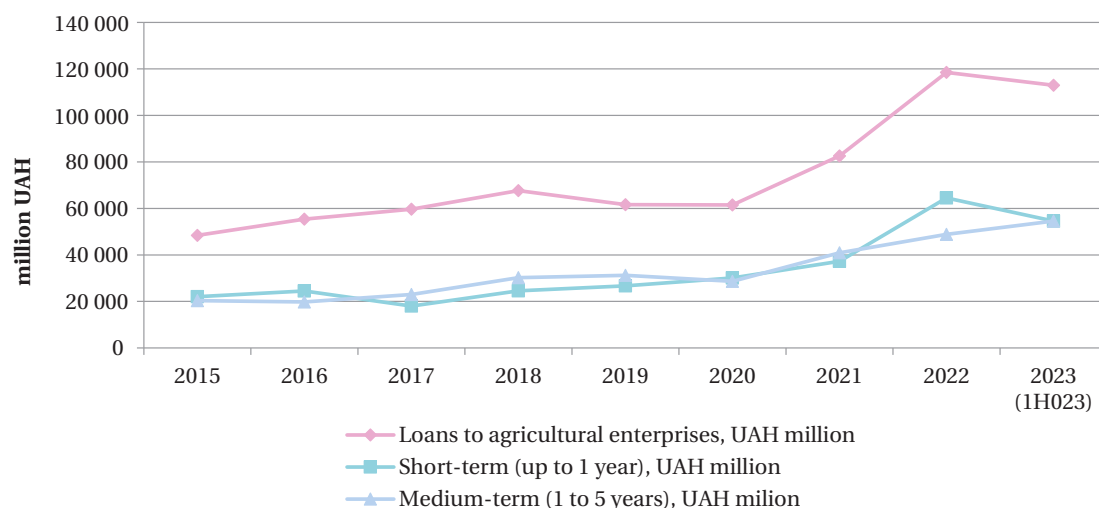


Figure 3. Current dynamics of lending to agriculture in Ukraine, 2015-2023 UAH million

Source: compiled according to statistical data from Financial Sector Statistics (n.d.)

In the first half of 2023, lending dynamics slowed slightly. The total amount of loans to agricultural enterprises decreased by 4.7% (or by UAH 5.5 billion). By maturity, short-term loans decreased by 15.4% (by almost UAH 10 billion), while medium-term loans increased by 11.7% (or almost UAH 6 billion).

Comparing the findings with the studies of other scholars, the complex of factors of demand for credit resources by agricultural enterprises, outlined by Yu.O. Lupenko & S.V. Andros (2019), it is necessary to add a catastrophic increase in the shortage of working capital among farmers as a result of a full-scale war. In contrast to the study by O.A. Sergienko & A.S. Gula (2018), who assessed the effectiveness of lending to the agro-industrial complex using the methods of cluster analysis and spatial multielement matrix, this paper substantiates and tests a structured toolkit for calculating credit load indicators and indicators of lending efficiency in agriculture by region of Ukraine.

The authors of this study can agree with the need to determine the relationship between the profitability of agricultural enterprises and interest rates on bank loans as a solid leverage to influence the further development of the business entity, as proved by O. Chygryn & O. Ivakhnenko (2020). It is worth supporting the opinion of scientists S. Arzhevitin *et al.* (2021) on the need to improve the mechanism for ensuring the availability of bank loans, develop effective loan products for the agro-industrial complex, and strengthen state support for lending to farmers. Unlike A. Bilochenko (2023), who assessed the dynamics of bank lending after the outbreak of war, this paper assesses the efficiency of agricultural lending and analyses the dynamics of state financial support. In continuation of the research by M. Nehrey & O. Trofimtseva (2022), who consider it necessary to expand state support for the agricultural sector in the form of providing access to cheap loans, this study analyses the positive dynamics of preferential lending to farmers during the war by region. O. Shpanel-Yukhta (2022) recognised the positive dynamics of growth in bank lending to agriculture in Ukraine during the war, while this study provides a ranking of banking institutions by agricultural lending in 2022-2023.

The conclusions of C.A. Ngong *et al.* (2022) argue that it is the prerogative of governments to encourage banking institutions to lend to the agricultural sector, and the authors of this study agree with them. M. Rizwan *et al.* (2019) and A. Khanal & O. Omobitan (2020) also focus their research findings on the need and priority of state influence on the activation and optimisation of bank lending mechanisms for agricultural producers (Shpychak *et al.*, 2022).

An interesting practice is the methodological substantiation and practical testing of measuring the impact of bank lending on improving the efficiency of green agricultural production in China, carried out by H. Wang & L. Du (2023). The possible application of the Panel Tobit economic-mathematical model in further research will help to structurally assess the regional differentiation of the impact of the size and cost of credit on agricultural production efficiency. The study by Y. He & L. Tauer (2023) deserves attention, as it focuses on an integrated assessment of the performance of American credit associations and the results of farms. M. Appiah-Twumasi *et al.* (2022) investigated the impact of innovative agricultural financing methods on the economic efficiency of Ghanaian farmers. A positive effect of the efficiency of innovative financing was established, which, according to the authors, indicates that the national policy should promote the creation of additional sources of informal financial opportunities for poor rural farmers in the form of rural savings and loan associations (Guliyev & Azizov, 2022).

R. Shibli *et al.* (2021) assessed the positive impact of agricultural credit on technical efficiency and crop yields of Malaysian farmers. The impact of credit on the agricultural productivity of Colombian farmers was also assessed by J. Rivera-Acosta & X. Xu (2023). As measurement indicators, the authors used natural indicators of the return on agricultural production per hectare and per employed worker. M.G. Koricho & M.H. Ahmed (2022) considered the impact of access to credit on the technical efficiency of smallholder maize farmers in Ethiopia. The authors conclude that credit services increase technical efficiency and help small farmers achieve the highest possible level of production from a given set of inputs.

According to the Official website of the State Statistics Service of Ukraine (n.d.), in 2022, Ukraine's economy posted a significant negative financial result of UAH 174.2 billion. Net profit amounted to UAH 731.3 billion, while a loss of UAH 906.5 billion completely offset the profitability of 66.2% of enterprises. Virtually all sectors of the country's economy, with the exception of agriculture, trade, finance, and insurance, suffered significant losses. Agriculture, forestry, and fisheries ended the first year of the war with a net profit of UAH 88.3 billion, almost twice as much as the wholesale and retail trade sector. Therewith, 78.6% of agricultural producers ended 2022 with a net profit of UAH 125.8 billion, while 21.4% of enterprises were unprofitable with a result of UAH 35.7 billion. Although the profitability of agriculture fell by 2.7 times (from UAH 240 billion to UAH 88.3 billion) compared to pre-war 2021, and the industry itself has suffered and continues to suffer significant losses and destruction, the loss ratio of the agricultural sector of the economy was the lowest compared to other areas of activity.

Therefore, support for the agricultural sector of the economy should be strengthened and expanded, both by the state and by credit institutions. The Ministry of Agrarian Policy, aware of the importance and need to support Ukrainian farmers, continues the State Programme "Affordable Loans 5-7-9%" to facilitate their access to bank credit resources under martial law and the programme of state guarantees (Strategy of the Ukraine's..., 2023). In 2022, 43 648 companies took advantage of concessional lending for a total of UAH 95.5 billion. Since the beginning of 2023, 10 743 agricultural enterprises have received loans worth UAH 53.7 billion under all lending programmes, including almost UAH 32 billion under the government programme "Affordable Loans 5-7-9%". In terms of regions, the largest amounts of credit resources were disbursed to farmers in Kyiv (UAH 10 billion), Vinnytsia (UAH 5.0 billion), Dnipro (UAH 4.8 billion), Kirovohrad (UAH 4.2 billion), and Odesa (UAH 3.8 billion) regions. According to the National Bank of Ukraine (Financial Sector Statistics, n.d.), the main drivers of agricultural lending during the war were Credit Agricole Bank, which provided loans worth UAH 11 billion, Privat Bank (UAH 9.5 billion), Oschadbank (UAH 8.9 billion), ProCredit Bank (UAH 5.4 billion), FUJB (UAH 5.0 billion), and Ukrgasbank (UAH 3.2 billion).

Similar to other sectors of the economy, the war has had a substantial impact on Ukrainian agriculture, reducing the efficiency of lending and reducing sales. Nevertheless, the agricultural sector stays one of the most resilient and profitable sectors, requiring further support from the government and lending institutions to ensure sustainable development and economic recovery.

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► Conclusions

The substantiation and practical implementation of the methodological approach to retrospective monitoring of the regional dynamics of credit burden indicators and the efficiency of lending to agricultural producers have revealed the following. In 2015-2022, lending to agricultural businesses showed a stable growth trend from UAH 48.4 billion to UAH 118.5 billion. Zhytomyr, Chernihiv, and Sumy oblasts are leading in terms of loan growth, while Kyiv, Kharkiv, and Dnipro oblasts are leading in terms of the volume of loans to the agricultural sector of the region. In 2022, agricultural lending increased by 43.4%. There has been a considerable increase in the share of lending to agriculture in total lending to the national economy – from 6.1% in 2015 to 15.7% in 2022. In the challenging conditions of a full-scale war, the cost of loans to agricultural producers in national currency increased 1.6 times – from 10% at the beginning to 16.7% at the end of 2022. In the first half of 2023, loans gained another 2.6% in price, from 16.7% to 19.3%.

The loan burden of the agricultural sector per business entity increased by 1.9 times in 2015-2021, from UAH 684.7 thousand to UAH 1 271.6 thousand. As of the beginning of 2022, the loan burden per person employed in agriculture stood at UAH 143.4 thousand, almost double the level of 2015. The leaders in terms of loan burden are Kyiv, Kharkiv, and Lviv oblasts. Lending efficiency in Ukraine increased by 1.74 times in 2015-2021, from UAH 4.95 to UAH 8.63 thousand of agricultural output per UAH 1 thousand of loans attracted. The volume of agricultural products sold per unit of loans attracted decreased by 3.8% (from UAH 7.0 to UAH 6.7 thousand). It was found that in 2015-2021, the efficiency of lending to the agricultural sector of the economy was twice as high as the overall economic indicator. However, during the first year of the full-scale war, the efficiency of lending in agriculture fell by 48% (from UAH 8.63 to UAH 4.51 thousand) and was 30% lower than the overall economic indicator.

Difficult realities require the improvement and development of mechanisms for state support for bank lending to the agricultural sector. This primarily concerns further optimisation of the regulatory framework for bank lending, simplification of the procedure for obtaining a bank loan, improvement of the mechanism for reducing the cost of loans, and introduction of effective economic incentives for commercial banks that intensify their lending relations with agricultural businesses.

► Acknowledgements

None.

► Conflict of Interest

The authors of this study declare no conflict of interest.

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Регіональний аспект ефективності кредитування аграрного сектору економіки України

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► **Анотація.** Сільське господарство України проявляє стійкість, адаптивність і виробничу гнучкість під час війни. Водночас пріоритетними проблемами є недостаток фінансових ресурсів для господарської діяльності, відновлення пошкоджених потужностей та забезпечення технологічної дисципліни. В цьому контексті, питання кредитування аграрних підприємств має значну актуальність. Метою дослідження було удосконалення та опрацювання методичного інструментарію оцінки кредитного навантаження та ефективності кредитування у сільському господарстві за регіонами України. У процесі дослідження використано ряд методів: порівняльного аналізу, табличний, графічний, статистичний, розрахунково-конструктивний, абстрактно-логічний. Протягом 2015-2022 рр. обсяги кредитування сільськогосподарських товаровиробників збільшились у 2,4 рази (тільки 2022 р. – на 43,5 % або на 35,9 млрд грн). За часткою залучених кредитів переважає Київська область (31 %). Питома вага кредитування аграрного сектору економіки зросла у 2,6 рази (від 6,1 до 15,7 %). Українські аграрії кредитуються переважно у національній валюті (76,4 % виданих кредитів) та на строки до року (54,4 %), від 1 до 5 років – 41,2 %. Протягом 2015-2021 рр. кредитне навантаження в розрахунку на один суб'єкт господарювання та на одного зайнятого зросло майже вдвічі. Найвищу ефективність кредитування демонстрували господарства Закарпатської, Житомирської, Рівненської, Луганської та Чернівецької областей. За перший рік повномасштабної війни ефективність кредитування у сільському господарстві впала на 48 % (від 8,63 до 4,49 тис. грн). Аграрні підприємства потребують підтримки, як з боку держави, так і з позиції кредитних установ. Практична значущість проведеного дослідження визначається удосконаленням інструментарію вимірювання рівня кредитного навантаження та оцінки ефективності кредитування в аграрному секторі економіки за регіонами України, що можуть бути використані органами державного та галузевого управління в регіональній практиці організації моніторингу та активізації практики державної фінансової підтримки сільських товаровиробників

► **Ключові слова:** показник кредитного навантаження; індикатор ефективності; державна підтримка; сільське господарство

ЕКОНОМІКА АПК
Науково-виробничий журнал

Том 30, № 5
2023

Літературний редактор:
В. Сова

Редагування бібліографічних списків:
В. Сова

Комп'ютерна верстка:
М. Кришталь

Підписано до друку 12.10.2023
Формат 60*84/8
Ум. друк. арк. 7
Наклад 50 прим.

Видавництво: Національний науковий центр «Інститут аграрної економіки»
03127, вул. Героїв Оборони, 10, м. Київ, Україна
E-mail: info@eapk.com.ua
www: <https://eapk.com.ua/uk>

EKONOMIKA APK
Scientific and Production Journal

Volume 30, No. 5
2023

Literary editor:
V. Sova

Editing bibliographic lists:
V. Sova

Desktop publishing:
M. Kryshthal

Signed to the print 12/10/2023
Format 60*84/8
Conventional Printed Sheet 7
Circulation 50 copies

Publisher: National Scientific Center "Institute of Agrarian Economics"
03127, 10 Heroiv Oborony Str., Kyiv, Ukraine
E-mail: info@eapk.com.ua
www: <https://eapk.com.ua/en>