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## The agricultural machinery market for crop production and prospects for its development in the postwar period

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**Abstract.** Due to the hostilities, the largest losses in the agricultural sector of Ukraine's economy were caused by the loss of agricultural machinery – 20.9% of it was destroyed or damaged. Therefore, ensuring the effective functioning of the market for agricultural machinery is a key factor in restoring the material and technical base of agricultural enterprises. The research aims to investigate the current state of the agricultural machinery market and the impact of military operations on it and to identify effective

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ways of its development. The following methods were used in the study: dialectical method of scientific knowledge, monographic, statistical, and economic, economic and mathematical, expert evaluation, and graphical. The general trend towards a decrease in the share of households with certain types of machinery in 2015–2022 is determined. Disproportions between large and small forms of management in the provision of machinery, as well as restrictions on access to financial resources for small agricultural enterprises, have been identified. The study identified a general decline in the size of the Ukrainian machinery market due to the loss of production capacity in the east and south of the country. Imports of agricultural machinery – tractors by 57.0%, combine harvesters by 30.0%, seeders by 33.8%, disc harrows by 45.1%, and cultivators by 38.9% – also decreased significantly in quantitative terms. The analysis of state support for agricultural machinery and agricultural enterprises is carried out. A forecast of the development of the agricultural machinery market for crop production under positive and negative scenarios, including risks and challenges that may arise during and after military operations, is made. Recommendations for the development of the market of agricultural machinery for crop production have been developed, including implementation of the state's protectionist policy; preservation of human resources; evacuation of agricultural machinery enterprises from the war zone; simplification of business to stimulate investment activity; state support for small farms, etc. The implementation of these recommendations will help restore the effective functioning of the agricultural machinery market and the logistics of agricultural production in Ukraine

**Keywords:** agricultural machinery market; imports; exports; state support; logistics

## INTRODUCTION

The market of agricultural machinery is a key element in the formation of an efficient material and technical base of agriculture. Unlike the markets of the vast majority of countries in the world, which are focused on small producers, the national market is oriented towards large and medium-sized enterprises. Machinery for small producers is of secondary importance in the market. Therefore, few studies reveal the specifics of the functioning of such a market. In addition, war has a significant negative impact on the functioning of the agricultural machinery market.

The current state of the market is characterised by fluctuations determined by the economic and political situation in a particular country and the world. Agricultural machinery and vehicles are distinguished by their specificity related to the working environment and conditions of use: difficult working conditions; seasonality of work; reliability; work on fields with uneven terrain; service maintenance, etc. (Durczak *et al.*, 2020).

J. Van Loon *et al.* (2020) identified the problems of small farms' access to mechanisation. The most common of these is the mismatch between the savings from machine power and the size of the farm – most of the world's food production is carried out by small farms, many of which have land in different places, which negates the efficiency of using more powerful machinery; the high cost of machinery makes it unaffordable for many, and financial support from the state and bank lending is limited; shortage of skilled workers and limited opportunities for their training. The authors see a way out in providing small farms with user-friendly machinery adapted to work in small fields and suitable for local business conditions. Technologies should be introduced that minimise negative social and environmental impacts.

Studying the evolution of agricultural mechanisation, D. Lewis *et al.* (2022) identified the most influential

factors: the expansion of input markets; the development of urban-rural linkages; and the climate crisis. The authors drew attention to the need to formulate policies for the development of mechanisation of small farms and small and medium-sized enterprises by taking into account local and national characteristics, obtaining proposals from various sources, and creating a database of these enterprises, in particular through public-private partnership experiments.

The problems of mechanisation development for small agricultural enterprises are also considered by Y. Wang & G. Huang (2022). They see their solution in using the services of specialised enterprises. To solve the problem of allocating shared agricultural machinery according to time windows, the researchers developed a two-stage system for dispatching the use of agricultural machinery with time windows.

The level of mechanisation among small farms was studied by T. Qiu & B. Luo (2021). They found a relationship between the size of the farm and the level of use of mechanisation services in agricultural production. R. Markov (2019) notes the need to intensify the processes of technical support of crop production enterprises in Ukraine, especially small farms, due to their limited access to machinery. He substantiates the need to improve an integrated approach to providing state support for the development of crop producers and domestic agricultural machinery enterprises. V. Mukha (2022), studying the Ukrainian agricultural machinery market during the coronavirus pandemic, noted its significant development in 2021. With the beginning of Russian aggression in 2022, there was an absolute drop in sales. In 2022, Ukrainian-made machinery, except for tractors, was in particular demand, with Chinese manufacturers retaining leadership in this segment.

The research aims to identify effective ways to develop the agricultural machinery market in the context of military operations and after their end. The research objectives are as follows: to determine the theoretical foundations of the agricultural machinery market and its relationship with market actors; to analyse the dynamics of the provision of enterprises with agricultural machinery, its production and import; the impact of the war on market development; to summarise the findings and provide practical recommendations for improving the functioning of the agricultural machinery market.

## MATERIALS AND METHODS

The analysis of the state of the agricultural machinery market and prospects for its development in the post-war period in Ukraine on a scientific basis is reflected in the relevant methodological approach. The scientific basis of the methodological approach to the analysis of technical and technological support of agricultural producers and export-import operations is theoretical support, practical principles of analysis and evaluation of this support, description of research methods, conditions of implementation, list of stages and expected results.

The methodological basis of the study is the dialectical method of cognition and a systematic approach to studying the development of the agricultural machinery market in Ukraine. At the same time, the following methods were used in the course of the study: monographic (in highlighting the views of scientists on the issues and problems studied in the work, in studying the current state of agricultural machinery in Ukraine); economic and statistical (in analysing foreign trade in agricultural machinery); tabular and graphical (in visualising the results of the study in the form of figures and tables); empirical (in studying the state of Ukrainian agricultural machinery and the sectoral machinery market in the wartime); comparative analysis (to identify the main problems of the development of the domestic agricultural machinery market in Ukraine); analytical forecasting method (to determine the tasks and recommendations for the organisational and economic mechanism of technical and technological support of agricultural producers in the post-war period); abstract and logical (generalisation and formulation of conclusions).

The statistical method is used to study the impact of factors of foreign economic activity and to forecast the situation on the agricultural machinery market in the post-war period. The characteristics of import operations change over time, and indicators of time series are used to assess the intensity of their development (Table 4, Figs. 2-4). The chain analysis method was used to obtain absolute and relative growth. The assessment is based on a comparison of imports and production volumes of machinery in the dynamics over different periods. The analysis was carried out both in general and by individual product groups in physical and value terms.

The study analyses the dynamics of import operations, in addition to studying the characteristics of import flows, and is supplemented by a study of the availability of agricultural machinery in enterprises and households, production volumes of the main types of agricultural machinery in Ukraine, the purchase of machinery under the partial compensation programme, and forecasts the development of the agricultural machinery market under optimistic and pessimistic scenarios. The system of indicators is built based on an indicative assessment using descriptive statistics and statistical analysis methods.

The information base of the study was based on the works of Ukrainian and foreign scholars, reference and information publications, and the regulatory framework of state economic regulation of the development of the agrarian sector of the economy (Official web portal of the Parliament of Ukraine, n.d.), statistical and analytical data of the Ministry of Agrarian Policy and Food of Ukraine (n.d.), the State Statistics Service of Ukraine (n.d.), the State Customs Service of Ukraine (n.d.), scientific electronic sources of information on the global computer network Internet, and the authors' observations.

## RESULTS AND DISCUSSIONS

Crop production is the basis of human nutrition, the feedstock for livestock, raw materials for industry, and thus the basis of the country's food security. A key condition for its efficient production is to provide agricultural enterprises with modern and high-performance agricultural machinery, which is impossible without a functioning agricultural machinery market. In the pre-war period, agricultural enterprises and households had the opportunity to constantly upgrade machinery, which, although not fully and in insufficient quantities, met production needs, while maintaining the general trend towards a reduction in the number of machinery in both agricultural enterprises and households. The issue of the availability of modern and high-performance machinery is particularly acute for small and medium-sized farms (Table 1).

The number of available machinery in the surveyed enterprises remained almost unchanged over the period, except for a significant drop in the availability of combine harvesters (29.3%) and harrows (17.5%) in 2019 compared to 2015. This decline is explained by the periodic mismatch between purchases and write-offs and fluctuations in demand, and applies to all types of machinery, as evidenced by a significant decrease in combine harvesters imports in 2018, when the availability of this type of machinery decreased (2,197 units), after significant imports in 2017 (3,250 units). The situation is similar for other types of machinery. The values of the indicator of machinery availability in households are even more unstable than in enterprises, which is related to their solvency and directly depends on agricultural prices.

Since statistical observations on the availability of equipment have not been conducted since 2020, 2019 figures are taken as the baseline. During the year of full-scale war, the largest losses in tractors were 9.1% (18203 units were destroyed and 10068 units were partially damaged) and the smallest losses in ploughs

were 2.1% (6363 units were destroyed and 241 units were partially damaged). The total losses of agriculture from the hostilities for the year amounted to 8717.7 million USD. USD, with losses of agricultural machinery destroyed and damaged amounting to 4655.7 million USD or 53.4%. USD or 53.4%.

**Table 1.** Dynamics of agricultural machinery availability in enterprises and households in 2015-2019\* and losses during full-scale military operations, thousand units

Vehicle type	2015	2016	2017	2018	2019	as of 24.03.2023	War losses, %***
Tractors**	127.9	132.7	129.3	128.7	130.5		
Tractors***	181.9	207.1	217.8	248.6	180.1	x	x
Tractors, total	309.8	339.8	347.1	377.3	310.6	282.3	-9.1
Combine harvesters**	37.5	37.9	36.6	26.3	26.5		
Combine harvesters***	18.8	14.8	15	16.6	14.6	x	x
Combine harvesters, total	56.3	52.7	51.6	42.9	41.1	38.7	-5.8
Planters**	65.5	67.2	66.3	65.1	66.5		
Planters***	93.8	98.8	127.5	130.9	122.5	x	x
Planters, total	159.3	166	193.8	196	189	178.1	-5.8
Ploughs**	47.3	49.3	49.1	49.9	51.4		
Ploughs***	313.2	284.3	287.6	301.9	258.8	x	x
Ploughs, total	360.5	333.6	336.7	351.8	310.2	303.6	-2.1
Cultivators**	69.5	71.7	70.1	70.5	71.6		
Cultivators***	129.4	112.1	119	139.7	121	x	x
Cultivators, total	198.9	183.8	189.1	210.2	192.6	180.2	-6.4
Harrows**	194.0	192.0	181.4	161.1	160.0		
Harrows***	427.4	378.6	400.2	363.7	342.6	x	x
Harrows, total	621.4	570.6	581.6	524.8	502.6	473.2	-5.8

**Note:** \*- since 2020, statistical observations on the availability of agricultural machinery in enterprises and households have not been conducted

\*\* - in agricultural enterprises

\*\*\* - In households

\*\*\*\* - from 24.02.2022 to 24.02.2023

**Source:** compiled by the author based on State Statistics Service (2015-2019) and Agricultural War Damages (2023) data

No statistical observations have been made since 2018. The calculated figure is based on the growth in the number and share of tractors with engine power over 90 kW in the total volume of tractor imports. Although the number of tractors in agricultural enterprises decreased from 1991 to 2017, from 497.3 thousand units to 129.3 thousand units, the average tractor engine power has been steadily increasing – from 63.2 kW in 1991 to 97.3 kW in 2017 (State Statistics Service of Ukraine, n.d.), and is estimated to reach 99 kW in 2021, which has increased their productivity. The growth of the average tractor power is influenced by the development of agricultural holdings that use

powerful machinery to cultivate large areas. Thus, in 2021, 4129 units of tractors with an engine power of more than 90 kW (13.7% of all imported units) were imported into Ukraine, while in 2017, only 2857 units (10.7%) were imported. Even in 2022, despite the outbreak of a full-scale war, their share in total tractor imports was 12.2% or 2040 units (State Statistics Service of Ukraine, n.d.).

An analysis of the availability of certain types of machinery in households indicates a downward trend in the share of these farms, although the share of households that owned agricultural machinery increased from 17.5% in 2015 to 20.0% in 2019 (Table 2).

**Table 2.** Share of households with agricultural machinery in use in 2015-2019\* and in 2022, %

Vehicle type	2015	2016	2017	2018	2019	2022**
Total	17.5	17.4	19.0	19.9	20.0	20.1
Tractors	31.2	24.6	23.7	27.2	19.2	19.4
Harvesters	2.3	1.8	1.7	1.7	1.6	1.7
Planters	13.9	12.4	14.5	14.3	13.1	13.2
Ploughs	37.3	34.6	31.3	32.0	27.3	27.5
Cultivators	15.8	14.1	13.4	15.0	13.2	13.3
Harrows	34.1	30.9	29.3	27.5	24.0	24.2

**Note:** \*Since 2020, statistical observations on “Share of households with agricultural machinery in use” have not been conducted

\*\* – calculated

**Source:** compiled by the author based on State Statistics Service (2015-2019)

The largest decrease was in the share of households that owned harrows – from 34.1% to 24.0%. The share of combine harvesters gradually decreased from 2.3% to 1.6% due to the constant increase in the cost of servicing this complex machinery (fuel, spare parts, machinery repair services, etc.). For the same reason, the share of tractor owners decreased significantly from 31.2% to 19.2%. Changes in the share of seeders and cultivators’ owners were insignificant. Fluctuations in this indicator are influenced by prices for agricultural products and energy resources, yields, crop cultivation technologies, cessation of agricultural activities and leasing of land to other farms, inflation, etc. During the period of full-scale military operations, considering 13% of the occupied territories, internal migration and physical loss of agricultural machinery, the share of households that had it in use decreased only in the temporarily occupied territories. In the territories of Ukraine free from occupation, the share of these farms increased slightly due to the evacuation of some of the equipment and its owners.

In 1991, independent Ukraine gained a powerful agricultural machine-building complex, which provided not only the Soviet Union with modern and

highly productive agricultural machinery but also exported a significant part of it to the countries of the socialist camp, as well as to Western Europe, Latin America, Africa, etc. For example, in 1990, Ukrainian factories produced 106,000 agricultural tractors alone, while the production of seeders amounted to 57,100 units (State Statistics Service of Ukraine, n.d.). Gradually, due to a decline in demand in the CIS countries – the main buyers of machinery, the use of outdated technologies in production, and a decrease in investment in the sector, Ukraine has largely lost its production and, consequently, export potential (Table 3).

The data reflects a general downward trend in agricultural machinery production and significant volatility due to several factors. After a long period of economic growth, the global financial crisis of 2008 led to a significant decline in machinery production. The economic growth in 2011-2012 was followed by a decline due to the internal economic crisis, loss of territories and the outbreak of hostilities in eastern Ukraine in 2014. The economic development of the country was negatively impacted by the COVID-19 pandemic in 2019-2020. In 2021, a slight recovery began, which was interrupted by Russian aggression.

**Table 3.** Dynamics of production of the main types of agricultural machinery for crop production in 2008-2021

Vehicle type	YEARS										±2021 to 2008, cases
	2008	2009	2011	2013	2014	2018	2019	2020	2021		
Wheeled tractors with power over 59 kW, thousand units	6.3	1.4	5.4	2.9	4.1	2.4	1.4	0.9	1.2	-5.3	
Combine harvesters, pcs.	309.0	56.0	399.0	68.0	c	47.0	c	c	c	-	
Ploughs, thsnd pcs.	7.1	5.3	6.1	6.2	2.0	3.0	2.5	2.7	2.3	-3.1	
Cultivators, thsnd pcs.	10.4	4.6	7.4	4.4	3.7	2.9	3.9	2.5	3.0	-3.4	
Disc harrows, thsd. units	5.5	1.1	7.4	2.0	2.0	2.2	2.1	2.3	3.5	-1.6	

Table 3, Continued

Vehicle type	YEARS									±2021 to 2008, cases
	2008	2009	2011	2013	2014	2018	2019	2020	2021	
Planters, thsnd pcs.	9.9	2.5	7.4	5.6	3.0	3.8	3.2	3.3	5.5	-1.8

**Note:** c - Data are confidential following the Law of Ukraine "On State Statistics".

**Source:** compiled by the author based on State Statistics Service (2008-2021)

During military operations, the impact of such factors as inflation, rising energy prices and the cost of logistics services is particularly acute. But without government support and foreign investment, the industry's recovery and innovative development is impossible. As a result of hostilities, seaport blockades, and inflationary processes in the country's economy, the level of agricultural machinery available to agricultural enterprises has significantly decreased. In addition, as of the beginning of 2023, 109.6 thousand units of agricultural machinery (14.3%) out of 764.3 thousand units were destroyed and 50.7 thousand units (6.6%) were damaged, and the total losses amounted to USD 4.7 billion – USD 4.3 and USD 0.4 billion respectively (Report on direct damage..., 2023)

The Kharkiv Tractor Plant, one of the country's largest manufacturers of a wide range of tractors of various capacities and tractors from 20 to 180 kW (Kharkiv Tractor Plant, 2023), was significantly damaged. The amount of damage is estimated at USD 44 billion (Report on direct damage..., 2022). The John Greaves plant in Berdiansk, which produced harvesters for various crops and tillage equipment, is now "producing anti-tank hedgehogs and stoves for the occupying army" (Who got MP Ponomaryov's plants in Berdiansk, 2023). The Orikhivsil-mash plant in Orikhiv, which produced tillage equipment, trailers, spreaders, etc. before the war, was heavily damaged (Ukrainian Armed Forces..., 2022). A significant reduction in the production of domestic machinery will have a negative impact, first and foremost, on the logistics of small and medium-sized farms.

Therefore, in the context of military operations, the government needs to take measures aimed at restoring the material and technical base of agricultural enterprises. The Cabinet of Ministers of Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 324, 2022)

amended the list of critical imports. In particular, several items under the UKTZED relating to agricultural machinery were classified as critical imports: sprayers and atomisers of plant protection products; machines for preparing or cultivating soil; (soil cultivation machinery, seeders and planters, distributors of mineral and organic fertilisers); tractors, in particular for agriculture and forestry. Before the outbreak of hostilities in 2022, the country's agricultural sector largely renewed its machine and tractor fleet with foreign machinery, which largely dominated the market. Often, agricultural enterprises prefer more efficient machinery from foreign manufacturers.

The leading countries producing tractors and other agricultural machinery – the United States, China and the European Union (Germany, France and the Netherlands) – were confidently promoting their products in Ukraine. Their share was 40-60% (State Customs Service of Ukraine). Manufacturers from such countries as the UK, Canada, Poland, and Belarus also held a prominent place in the market. The negative balance between exports and imports contributes to a significant outflow of foreign currency from the country, loss of competitive advantages of domestic machine builders' products in foreign markets, migration of skilled labour abroad, and undermining of the economy as a whole due to critical import dependence.

An analysis of the dynamics of machinery imports confirms the significant dependence of Ukrainian agricultural production on foreign machinery. The peculiarity of the machinery market is that a significant segment of it is occupied by Chinese products, which have attractive prices and are gradually improving in quality. Tillers are in particular demand among households and small farms, as well as mini tractors (Table 4).

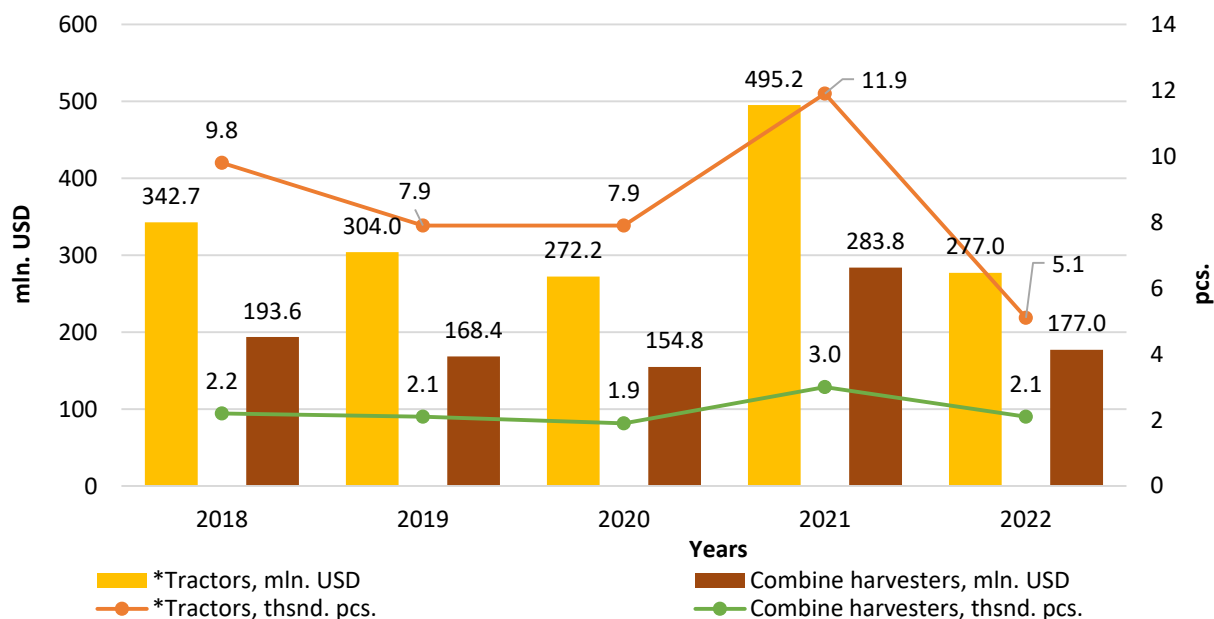
Table 4. Dynamics of imports of monoblocks and mini-tractors in 2017-2022

Vehicle type	measurement unit	Years					2022 to 2021, ± %
		2018	2019	2020	2021	2022	
Motorblocks	thsnd pcs.	47.5	31.2	40.1	34.8	28.3	-18.7
	mln. USD	10.7	7.6	9.2	10.4	7.4	-28.8
Mini tractors with engine power up to 37 kW	thsnd pcs.	22.5	16.3	18.8	18.7	11.6	-37.9
	mln. USD	50.1	40.8	46.4	53.5	35.4	-33.8

**Source:** compiled by the author based on State Statistics Service (2017-2022)

Before the outbreak of hostilities, imports of monoblocks and mini-tractors were fairly stable. The hostilities led to an economic crisis and the loss of some territories contributed to a significant reduction in imports

of not only mini-tractors and walk-behind tractors but also other machinery. Imports of tractors with engine power over 37 kW decreased by 57.1% in quantity and 44.1% in value (Fig. 1).



**Figure 1.** Dynamics of imports of tractors and combined harvesters in 2018-2022

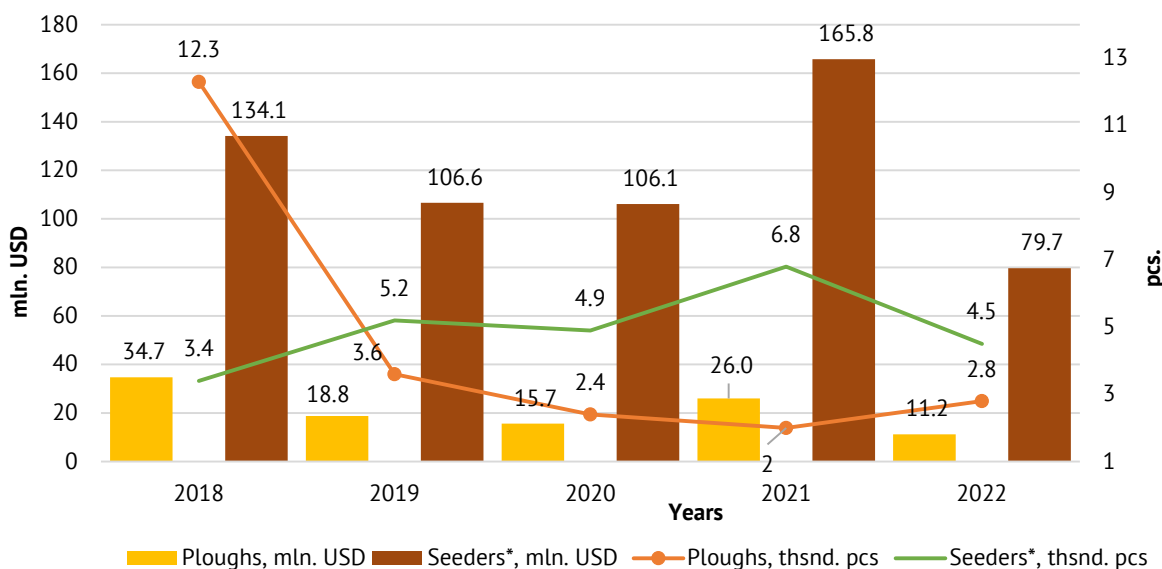
**Note:** \* – Tractors with an engine power of more than 37 kW

**Source:** compiled by the author based on State Statistics Service (2018-2022)

This disproportion is explained by the rising cost of machinery due to increased production and logistics costs. The reduction in imports of combine harvesters in 2022 compared to 2021 is significant in terms of quantity and value (30.0% and 37.6%, respectively), but its volumes are at the level of 2019 and slightly higher than in 2020 due to unmet demand for this type of equipment and significant losses due to hostilities.

In 2018, 10.8 thousand units of ploughs (87.8%) for motorblocks and mini-tractors were imported from

China with a customs value of only USD 288.1 thousand (0.82%), which explains the imbalance between the large number and relatively low value of imported machines. In 2021, for example, only 0.55 thousand units of ploughs (27.2%) were imported from China with a customs value of 29.9 thousand USD (0.1%), so the total customs value of imports is relatively high – 26.0 million USD. In 2022, 2.1 thousand ploughs were imported from China with a customs value of only USD 14 thousand (Fig. 2).



**Figure 2.** Dynamics of imports of ploughs and seeders in 2018-2022

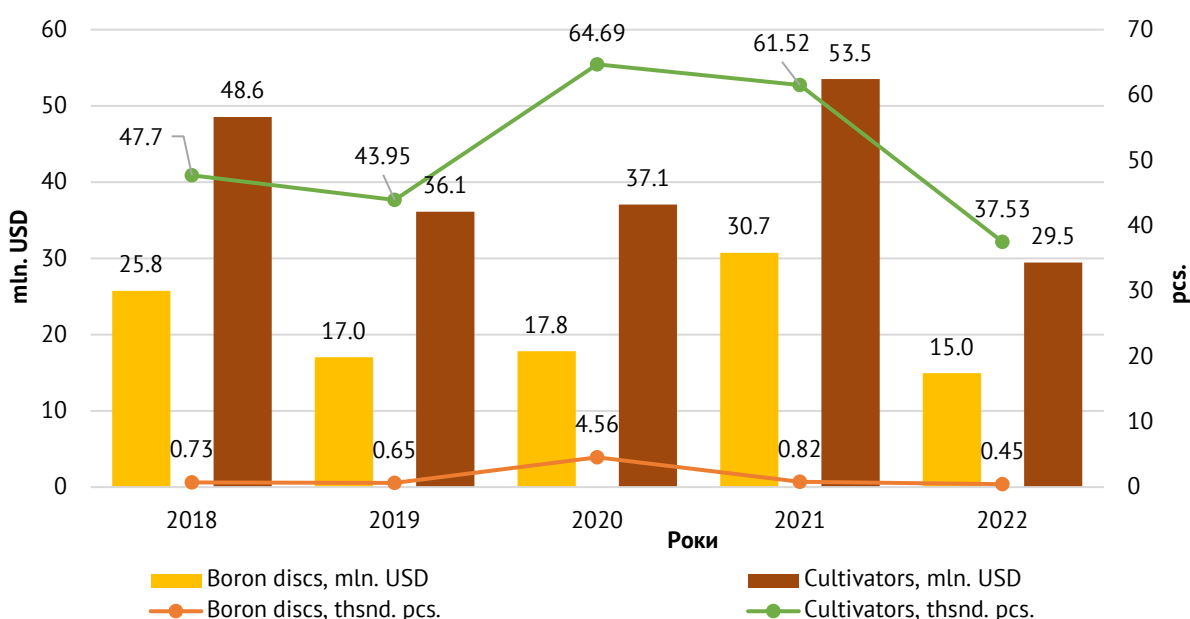
**Note:** \* – Seeders, planters, and seedling machines

**Source:** compiled by the author based on State Statistics Service (2018-2022)

Seeders were imported from 3.4 thousand units in 2018 to 6.8 thousand units in 2021 with a customs value of 79.7 million USD during the study period. USD in 2022 to 165.8 million USD in 2021. In 2022, 69.8% of seeders were imported from China, and their customs value was only 3.5% of the value of all imported seeders, which indicates the demand for them among small farms and households. Disc harrows are imported to Ukraine in small quantities (Fig. 3), which is explained by their sufficient domestic production. In 2020, 3,929 units of harrows (86.2%) for motorblocks were imported from India with a low average customs value of only 4.6 USD (State Statistics Service of Ukraine). Despite significant domestic production of cultivators, the vast majority of miniature machinery is imported from

China – in 2022, imports accounted for 96.9% in quantity and only 15.5% in value.

The expansion of Chinese machinery for use in small areas hurts the development of domestic agricultural machinery. While the limited production capacity of self-propelled machinery can be partially justified by the complexity of technological processes and lack of personnel and necessary equipment, Ukraine has all the capabilities to produce trailed implements and units for motorblocks and mini-tractors – production facilities, personnel, and raw materials. The production of mini-machinery during the post-war reconstruction period would create new jobs, increase tax revenues and save foreign currency, which is so necessary for a country in a state of war and post-war economic recovery.



**Figure 3.** Dynamics of imports of disc harrows and cultivators in 2018-2022

**Source:** compiled by the author based on State Statistics Service (2018-2022)

It is worth noting that Chinese products are gradually occupying not only the segment of mini-machinery in the market but are also confidently covering the segments of more powerful machinery. For example, in 2017, only 40 units of Chinese-made tractors with an engine power of more than 90 kW were imported to Ukraine, while in 2018 the volume of imports was 216 units, and in 2019 – 241 units. In 2020, 547 units of tractors with an engine power of 75-130 kW were imported from China, and in 2021, imports reached a record high of 1,546 units. In the same year, tractors with a capacity of more than 130 kW were imported for the first time in the amount of 9 units. Due to the outbreak of hostilities and a decline in demand for Chinese high-power tractors, fewer Chinese tractors were imported in 2022 than in the previous year: 706 units with an engine power of 75-130 kW and 9 units with an engine power of more than 130 kW (State Statistics Service of Ukraine). In

recent years, Chinese machinery started to confidently compete not only with domestic and CIS machinery but also with the best global brands due to its affordable price, improved quality, and performance.

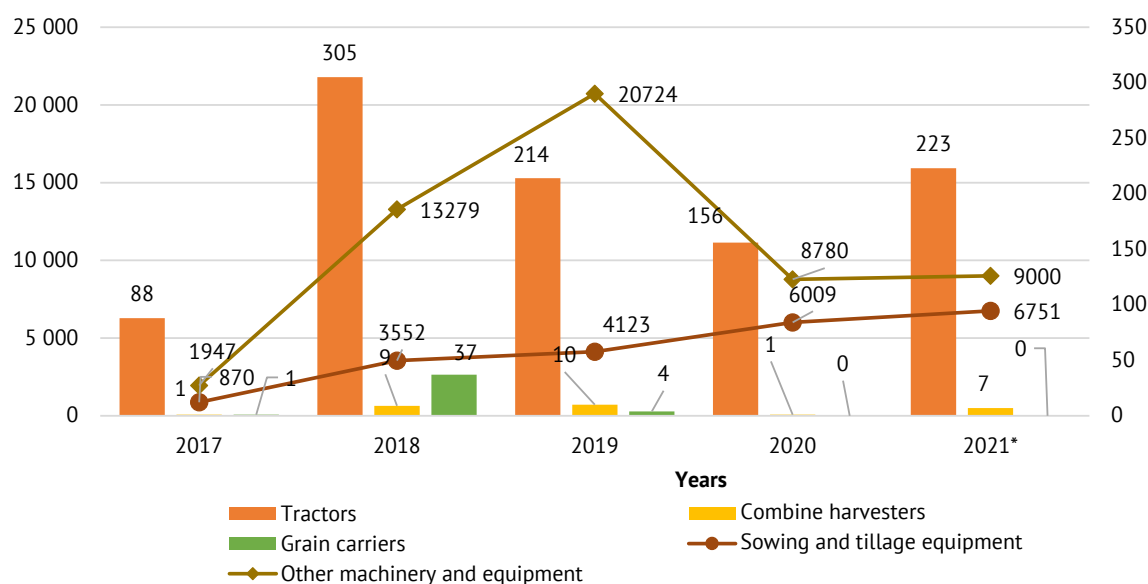
At various times, Ukraine has adopted legislative acts and programmes aimed at stimulating the technical and technological modernisation of agricultural production, in particular by stimulating demand for domestic agricultural machinery. The most effective programme was the Programme of Partial Compensation for the Cost of Domestic Agricultural Machinery and Equipment, which was renewed in 2017 (Resolution of the Cabinet of Ministers of Ukraine No. 130). Although the programme did not start well in 2017, with only UAH 134.1 million of the planned UAH 550 million being used, it proved to be quite viable. A total of 1,220 companies participated in the programme and purchased 2,906 pieces of equipment for a total



of UAH 670.3 million (excluding VAT) with a 20% compensation. The farmers purchased 88 tractors, 1 grain carrier, 870 units of tillage and sowing equipment, and 1947 units of agricultural equipment (Fig. 4).

In 2018, the programme's funding increased, and the interest of participants grew: UAH 912.9 million (96%) of the UAH 955.0 million budgeted was spent, the number of participants reached 7,043, and the

compensation rate increased to 25%. We purchased 17182 units of agricultural machinery and equipment worth UAH 3651.8 million. In 2021, with a budget of UAH 991.35 million, 5789 enterprises purchased almost 30 thousand units of machinery. Since the data on certain types of equipment are not published, the experts of the Institute of Agrarian Economics have calculated the approximate number of sales.



**Figure 4.** Purchase of agricultural machinery under the partial cost compensation programme, units

**Source:** compiled by the author based on data (The Ministry of Agrarian Policy and Food of Ukraine, n.d.).

**Note:** \*2021 – estimated

Due to the military operations in 2022 and 2023, the Partial Compensation Programme for Agricultural Machinery was suspended. Given the destruction of some agricultural machinery companies and the destruction of agricultural machinery, the resumption of the programme in 2024 could be a powerful compensation for the losses incurred. To support small and medium-sized agricultural producers during the war, a soft loan programme was introduced (Resolution of the Cabinet of Ministers of Ukraine No. 274, 2022). Only small and medium-sized agricultural producers can participate in this programme. Their turnover should not exceed EUR 20 million per year (equivalent to enterprises that cultivate up to 10,000 hectares). The maximum loan amount is UAH 50 million, the loan term is 6 months, and the purpose is to carry out agricultural activities for the period of martial law (at 0 per cent per annum, and in case of termination of martial law – until the end of the loan term). The maximum amount of the state guarantee for portfolio loans is up to 80%.

The proposed measures will ensure the timely and full implementation of a set of necessary technological operations in critical conditions of hostilities, which will help ensure a high level of food security in Ukraine. As of December 2022, the inflation rate for non-energy

industrial products in the euro area was 6.4%, and as of 1 May 2023, although it decreased to 6.2%, it remains quite high, which will lead to an increase in prices for agricultural machinery from European manufacturers, the main suppliers to Ukraine. In addition, high logistics costs remain a significant factor behind the rise in machinery prices. After all, the inflation rate in the energy sector was 25.5% in December 2022 and decreased to 2.5% as of 1 May (Official website of the European Union, n.d.). This will increase demand for new and foreign-used equipment and decrease demand for new foreign equipment. Low domestic prices for agricultural products, primarily oilseeds and grains, will also reduce demand for expensive imported machinery.

The aforementioned factors will lead to a decrease in imports of machinery in quantitative terms in 2023 compared to 2022: tillage machinery – by 25-30%; harvesting machinery – by 15-20%; and agricultural tractors – by 20-25%. Considering the analysis of the current state of the agricultural machinery market, its further development can be seen in two scenarios – positive and negative.

The positive scenario envisages: rebuilding and modernising the domestic agricultural machinery industry through foreign investment; government support for agricultural machinery, which will increase demand

for Ukrainian-made machinery; entry of domestic machinery into new foreign markets in Eastern Europe and Africa, where it will become fully competitive; prioritising the production of mini-machinery and gradually driving cheap foreign machinery out of the market; favourable investment climate, cheap energy resources, and skilled personnel will facilitate the production of equipment of the world's best brands and the creation of joint ventures based on domestic facilities; creation of new jobs at the restored enterprises.

Under the negative scenario, the loss of the existing, most high-tech agricultural machinery enterprises and the lack of budgetary funds for their restoration should be expected; production of only simple, low-tech machinery and equipment for soil preparation or cultivation; minimisation of purchases of new machinery, restoration of existing machinery and purchase of used machinery by the vast majority of agricultural enterprises; unfavourable investment climate and difficult business conditions; expansion of foreign equipment, mostly of low quality; loss of human resources in the machine-building industry due to war losses and migration abroad.

Therefore, to overcome the negative effects of the war on the development of the agricultural machinery market and the logistics of agricultural production, it is necessary to create a favourable investment climate to attract investment in the development and restoration of domestic machinery production, and to organise joint ventures to produce innovative, high-performance and environmentally friendly machinery; simplification of the business and licensing system, reduction of bureaucratic procedures and elimination of corruption in the process of setting up enterprises; implementation of protectionist policies by the state to limit imports of low-quality machinery at dumping prices by introducing quotas and raising duty rates; resumption of state programmes aimed at financing the restoration and development of domestic agricultural machinery; and state incentives to increase the production of miniature machinery; involvement of households and small farms in state targeted programmes for the development of the agricultural sector; creation of the most favoured nation regime for critical imports of machinery through a mechanism of reducing tax pressure; evacuation of agricultural machinery enterprises and their employees from the war zone, and training of new specialists.

Only the adoption and clear implementation of a comprehensive programme to restore the agricultural machinery industry and support agricultural producers will contribute to the sustainable development of the agricultural sector in the post-war period. S. Késmárki-Gally *et al.* (2020) determined that adverse weather conditions limit the time spent on agricultural work and encourage farmers to consider purchasing more powerful machines. This is also caused by a

significant and persistent labour shortage in agricultural production. At the same time, farmers are faced with a choice: to use modern, innovative machinery or to purchase simpler and cheaper equipment. For Ukraine, during and after the hostilities, the issue of combining these factors is acute, given the significant loss of equipment and the crisis economic situation. Therefore, the use of used, cheap but innovative equipment is particularly relevant today and will remain a priority for several post-war years.

G. Lobos *et al.* (2021) confirmed that the price of tractors decreases with age, increases with decreasing tractor power, and significantly depends on the manufacturer's brand. In Ukraine, used high-capacity tractors made in Europe and the US are preferred, while mini tractors are preferred from Japan. In 2022, imports of used tractors with an engine power of more than 130 kW from the US and Germany accounted for 84.5%, and from Japan – 97.8% (engine power up to 18 kW) (State Statistics Service of Ukraine). M. Jaleta *et al.* (2019) examined the mechanisation of agricultural production and the reduction of soil impact in the process of tillage in the context of sustainable intensification in developing countries. According to the authors, soil conservation, the speed of technological operations and energy savings in the production process are factors that contribute to the spread of minimum tillage. In Ukraine, the introduction of these technologies is particularly relevant during and after the war period. First and foremost, it saves energy resources in the face of their significant shortage and high cost, as well as reduces depreciation of technical equipment and the cost of their repair. This approach will have a positive impact on the efficiency of agricultural enterprises in the context of high inflation and low prices for agricultural products.

According to the authors, the statement proposed by S. Marchenko & A. Voropaev (2019) that “today, the equipment of Ukrainian manufacturers meets modern requirements for technical condition, build quality, safety, and price. And foreign consumers are ready to buy Ukrainian machinery...” is debatable. After all, exports of domestic machinery are quite low compared to imports of foreign machinery. Ukraine's partner countries were CIS countries with a relatively low level of agricultural machinery development. Until 2019, Russia was the main consumer of domestic products. For example, in 2017-2018, Russia ranked first among the importing countries of Ukrainian tractors in the amount of USD 13.1 (95.3%) and 5.0 (77.6%) million and seeders in the amount of USD 16.2 (82.1%) and 10.5 (73.6%) million, respectively. But first, it restricted the import of Ukrainian machinery into its territory, and from 24 February 2022, all exports to Russia were suspended. With the loss of Russian markets, there was a sharp drop in exports of certain types of domestic machinery (tractors, ploughs). In 2019-2021, exports of tractors amounted to only USD 1.9 million, USD 1.2 million, and USD 642.5

thousand, respectively. Import partners of domestic tractors were Romania, the Republic of Moldova, Bulgaria, Kazakhstan, etc. (State Customs Service of Ukraine). In 2019-2021, Ukrainian-made seeders were exported to Belarus, Kazakhstan, Moldova, Bulgaria, etc. It should be noted that seeders are one of the few types of machinery that meet high standards and whose exports have been consistently high.

According to O. Boltianskyi & N. Boltianska (2020), there are significant problems in the production of Ukrainian agricultural machinery due to the production of identical machinery in many enterprises. Each enterprise produces it using imperfect technology and low-quality materials, which makes the reliability and durability of the machine's working parts three times lower than that of foreign analogues. In addition, the decline in sales of Ukrainian-made machinery has led to a loss of human resources in the agricultural machinery industry, resulting in a decline in product quality and, consequently, a decrease in competitiveness.

R. Vidosa *et al.* (2022) studied the patterns of use of the ISO 11783 (ISOBUS) standard in the production of agricultural machinery. The ISO 11783 standard, which is widely used globally, will become mandatory for successful entry into foreign markets. The expansion of agricultural machinery by multinationals to Latin American countries may deprive local companies of the ability to maintain their market share. A similar situation may arise in the Ukrainian agricultural machinery market. After all, the Ukrainian machine-building industry operates according to old standards that currently meet the requirements of only the domestic market and the markets of a limited number of countries, including the CIS. Therefore, the issue of the transition of agricultural machinery production to new standards will arise after the end of hostilities in Ukraine. Otherwise, the expansion of foreign machinery will completely displace Ukrainian products due to their inability to compete with it.

In our opinion, it is reasonable to identify the factors that influence the decline in production of agricultural machinery enterprises during the crisis period: "The main negative factors that determine the decline in industry performance during the intensive unfolding of the economic crisis are a drop in the solvency of enterprises, and an increase in production costs. The synergistic effect of the simultaneous action of these destructive factors has led to the crisis rate of industrial decline" (Abuselidze *et al.*, 2022). It is quite appropriate that H. Tong *et al.* (2020) note the impact of state support on the quality of agricultural machinery and production costs, but it is not unambiguous – the growth of profits is not equivalent to quality improvement. Therefore, a condition for financing state support programmes for domestic machine building should be the condition of investing in the innovative development of the enterprise and improving product quality.

## CONCLUSIONS

Exports of agricultural machinery from Ukraine are significantly lower than imports. Until 24 February 2022, Russia was the main importer of Ukrainian agricultural machinery. Since the outbreak of the war, this market has been lost, resulting in a sharp drop in exports of certain types of machinery. The key importing partners of domestic tractors were Romania, the Republic of Moldova, Bulgaria, Kazakhstan, and seeders – Kazakhstan, Moldova, and Bulgaria.

During the hostilities, the impact of inflation, rising energy prices and the cost of logistics services on the supply and demand for machinery was particularly acute. A significant number of agricultural machinery companies have been damaged, destroyed or are under occupation, which has also reduced the presence of Ukrainian machinery on the market. As a result of the hostilities, blocking of seaports, inflation and increased logistics costs, the availability of agricultural machinery to agricultural producers has decreased. As of 24 February 2023, 160.3 (20.9%) thousand units of equipment out of 764.3 thousand units were destroyed or damaged, and the total losses in value amounted to USD 4.7 billion.

The decline in machinery production in Ukraine will primarily hurt the availability of machinery for small and medium-sized agricultural producers. Therefore, the government's activities should be aimed primarily at restoring the logistics of agricultural enterprises, and the government's relaunch of the Programme for Partial Compensation of the Cost of Agricultural Machinery and Equipment should be a key factor in this recovery. In 2021, the budget of the Programme was UAH 991.35 million, which allowed 5789 agricultural producers to purchase almost 30 thousand units of equipment. However, the hostilities prevented the Programme from being funded in 2022 and 2023.

Foreign machinery plays a leading role in updating the material and technical base of agricultural enterprises. The main exporters of agricultural machinery to Ukraine were the United States, the European Union (Germany, France, and the Netherlands), Belarus and China. Their share was 40-60%. China became the main importer of mini-machinery. In 2023, due to the negative impact of hostilities, imports of machinery may decrease in quantitative terms compared to 2022: tillage machinery – by 25-30%; harvesting machinery – by 15-20%; and agricultural tractors – by 20-25%. The positive and negative scenarios for the development of the Ukrainian agricultural machinery market considered in the study indicate the possibility of a full recovery of the Ukrainian agricultural machinery industry, saturation of the market with domestic competitive machinery and access to new foreign markets for its sales, or the loss of Ukrainian machinery positions in the market and complete dependence on imported machinery.

Therefore, to overcome the negative effects of the war and intensify the development of the agricultural

machinery market, as well as to meet the full demand for agricultural machinery, it is necessary to improve the investment climate, organise joint production with the world's leading agricultural machinery manufacturers, and implement a protectionist state policy aimed at protecting domestic production, restoration of state support for the restoration and development of domestic agricultural machinery, support for the development of technical support for small businesses in rural areas. The prospect of further research will be to study the state of the Ukrainian agricultural machinery industry

as a key link in the machinery market, to reveal the reasons for the decline in its efficiency and determine the volume of losses as a result of military operations, and to formulate effective proposals for its restoration and improvement.

None.

None.

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## CONFLICT OF INTERESTS

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## Ринок сільськогосподарської техніки для рослинництва та перспективи його розвитку у повоєнний період

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**Анотація.** Через воєнні дії найбільшими втратами аграрного сектору економіки України стали втрати сільськогосподарської техніки – знищено і пошкоджено 20,9 %. Тому, забезпечення ефективного функціонування ринку технічних засобів для села є ключовим чинником відновлення матеріально-технічної бази сільськогосподарських підприємств. Метою роботи було дослідити сучасний стан ринку сільськогосподарської техніки та вплив на нього воєнних дій, визначити ефективні шляхи його розвитку. У процесі дослідження були використані наступні методи: діалектичний метод наукового пізнання, монографічний, статистико-економічний, економіко-математичний, експертних оцінок, графічний. Визначено загальну тенденцію до скорочення протягом 2015-2022 років частки господарств населення, які мають окремі види техніки. Виявлено диспропорції між великими та малими формами господарювання у забезпеченні технікою, а також обмеження доступу до фінансових ресурсів малих сільськогосподарських підприємств. У процесі дослідження визначено загальне скорочення обсягів ринку української техніки через втрату виробничих потужностей на сході та півдні країни. Також значно скоротився імпорт сільськогосподарської техніки – тракторів на 57,0 %, комбайнів зернозбиральних на 30,0 %, сівалок на 33,8 %, борін дискових на 45,1 %, культиваторів на 38,9 % у кількісному виразі. Здійснено аналіз державної підтримки сільськогосподарського машинобудування та аграрних підприємств. Сформовано прогноз розвитку ринку сільськогосподарської техніки для рослинництва за позитивним та негативним сценаріями, що включають ризики та виклики, які можуть виникнути під час воєнних дій та після їх завершення. Розроблено рекомендації щодо розвитку ринку сільськогосподарської техніки для рослинництва, що передбачають: здійснення протекціоністської політики держави; збереження кадрового потенціалу; евакуацію підприємств сільськогосподарського машинобудування із зони бойових дій, спрощення ведення бізнесу для стимулювання інвестиційної діяльності, державну підтримку малих фермерських господарств тощо. Виконання цих рекомендацій сприятиме відновленню ефективного функціонування ринку сільськогосподарської техніки та матеріально-технічного забезпечення аграрного виробництва в Україні

**Ключові слова:** ринок сільськогосподарської техніки; імпорт; експорт; державна підтримка; матеріально-технічне забезпечення