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Development of grain logistics in Ukraine

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► **Abstract.** In the modern environment, new dangers are emerging that affect the current situation of grain logistics in Ukraine and must be countered to offset their adverse impact. The purpose of this study was to investigate the current trends in the grain logistics market and identify emerging challenges and threats, as well as to formulate an algorithm of actions for the development of the agricultural sector infrastructure during and after the war. When considering the problems and objectives of the study, the authors of the study employed scientific methods, namely: dialectical, systematic approach, comparative analysis, tabular and graphical, monographic, and deductive, which determined the method and sequence of solving the tasks. The study analysed the monthly dynamics of grain cargo transportation by rail for 2021-2024. The tariffs for internal and international transportation of grain crops by road, as well as the cost of procurement services of the branches of the Joint Stock Company "State Food and Grain Corporation of Ukraine" were investigated. The study found that during the period of martial law, the grain business adapted to the conditions that arose and was gradually restoring damaged property, expanding existing capacities, and building new ones. The study showed that in 2023-2024, 1.9 million tonnes of elevator capacities were built in the regions of Ukraine, including transshipment terminals, and the total elevator capacity at the beginning of 2024 was approximately 41.4 million tonnes. The key factors that contributed to the normalisation of trade logistics in 2022 were substantiated. The study analysed the exports and imports of grain crops by various modes of transport and examined the main buying countries and the largest exporters of Ukrainian grain. The study provides a scientific substantiation for the EU-Ukraine Solidarity Road Initiative. A reasoning was provided for the algorithm of actions for further development of the agricultural sector infrastructure during and after the end of the war to rebuild it. The use of the proposals set out in this study will enable a better assessment of the state of Ukraine's grain logistics during

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the war and post-war reconstruction. The proposals and practical recommendations of the study may be useful for government officials, farmers, and other agricultural producers, as they can be used to develop relevant programmes and measures to support the development of grain logistics in Ukraine

► **Keywords:** transportation; storage of products; railway; elevator capacities; ports of Greater Odesa; action algorithm

► Introduction

Ukraine is one of the world's largest grain producers and exporters. Prior to the outbreak of hostilities, over 70% of Ukraine's grain production was exported, with over 90% of exports taking place by sea via Black Sea ports (Yanovska *et al.*, 2025). Grain production and exports are one of the pillars of the country's modern economy. In the 2022/2023 marketing year, Ukraine ranked 6th (15 million tonnes) among the world's largest exporting countries, behind Russia (44.5 million tonnes), Australia (32.5 million tonnes), Canada (26 million tonnes), the United States (21.1 million tonnes), and France (18 million tonnes) (TOP-10 wheat producing countries..., 2023). In 2024, the volume of agricultural exports reached the pre-war level and amounted to USD 24.5 bn (78.3 million tonnes) or 59% of total exports. Significant exports (48.2% of total agricultural exports) were accounted for by cereals: maize – 29.6 million tonnes (USD 5 bn); winter wheat – 20.6 million tonnes (USD 3.7 bn); rapeseed – 3.8 million tonnes (USD 1.8 bn); soybeans – 3.4 million tonnes (USD 1.3 bn) (Historical record..., 2025). One of the determining factors in achieving such prominent results during the hostilities was the restored grain logistics, which necessitated its more thorough study and the development of areas for its effective functioning in the context of instability and post-war reconstruction.

Y.J. Kim & B.K. Lee (2022) focused on preventing grain spoilage and preserving its qualities through the widespread use of containers and grain logistics systems. The researchers found that the cost of containerised grain transportation was lower than that of conventional bulk grain. Y. Rudyk *et al.* (2023) developed methods for evaluating logistics facilities based on their geographical location and active user involvement. They will facilitate the development of new, safe routes as an element in the food supply chain, including grain.

H. Kryshstal (2023) investigated the development of agrarian logistics during military operations, reflecting both theoretical aspects (definition of logistics and agrarian logistics) and analysing the overall state of agrarian logistics and grain logistics specifically. The researcher proved that without improvement of logistics it would be impossible to unlock the full potential of the country's agricultural sector. The regression models developed by V. Kolodiichuk & Yu. Dubnevych (2020) are advisable to be used to predict the performance indicators of grain logistics systems. The conceptual model developed by A. Muradian *et al.* (2023), The Smart Port, through the symbiosis of the theoretical foundations of technological development and the UN Sustainable Development Goals, will contribute to the expansion of the modern scientific foundations of transport logistics systems. The researchers identified the prospects for growth to the fourth category of development of Ukrainian ports, and a model for optimising the management of logistics flows for their successful development by 2038 was proposed.

H. Kryshstal (2023) identified the key development vectors of Ukrainian agriculture during the military operations, namely: increasing the area under export-oriented crops, promoting job growth in rural areas, breeding new varieties, modernising processing enterprises and grain logistics infrastructure. D.-Y. Li *et al.* (2023) investigated the third-generation Beidou navigation positioning system and the benefits of its use in logistics tracking and emergency management in the grain industry. L.-G. Ji *et al.* (2023) identified priority areas for the development of grain logistics, including progressive approaches to planning grain logistics facilities, improvement of logistics hubs, technical re-equipment, optimisation of multimodal traffic flows, and management and control systems. The researchers paid particular attention to the use of intelligent innovative technologies and training of highly qualified personnel in logistics.

N. Potori & Z. Molnár (2024) highlighted the problem of disruption of export-import logistics links in the transportation of maize caused by military operations in Ukraine, providing a detailed analysis of changes in the structure of bilateral trade and describing the effects of these disruptions. Therewith, the researchers substantiated the temporary nature of this phenomenon, the absence of threats to the EU grain market, and the significance of adaptive and secure logistics in the face of geopolitical instability. E.S. Farias & M.A.S. Martins (2023) investigated the choice of the best location for the establishment of distribution centres, factoring in the delivery of crop products to consumers at minimal cost. Their developed mathematical model for optimising wheat logistics costs can be adapted to other sectors of agricultural production. A.B. Hemmelgarn *et al.* (2023) considered an alternative technology for harvesting main production and by-products of grain, based on a single-pass system where main products and by-products are harvested as bulk material, stored and preserved by anaerobic fermentation, and subsequently transported together to a processing plant.

The purpose of the present study was to assess the current state and trends, identify challenges and threats in the field of grain logistics, as well as substantiate and shape the development vectors of grain logistics infrastructure in the context of instability and the post-war period. The objectives of the study were as follows: to study and systematise scientific evidence in improving and developing the grain logistics sector; to analyse the current state and features of grain logistics in Ukraine; to analyse grain exports by various modes of transport.

► Materials and methods

The basis of theoretical research on grain logistics in Ukraine included the scientific studies of researchers who addressed this issue. The study used data from the

State Statistics Service of Ukraine (n.d.) (on gross harvest of cereals and legumes in weight after processing), data from the State Customs Service of Ukraine (Exports of Ukrainian..., 2024) and the Ministry of Agrarian Policy and Food of Ukraine (2025), data from the State Food and Grain Company of Ukraine (Cost of procurement..., n.d.), data from the global network regarding information on monthly volumes of grain transportation in 2021-2024 of the Ukrainian Railways (Grain transportation..., 2024), as well as data from logistics companies (on the cost of internal and international grain transportation in 2024 (Ukratologic Group, n.d.), information from the country's main elevator website Elevatorist.com (Grain storage capacities..., 2024).

The study of grain logistics in Ukraine was conducted based on the dialectical method. The application of this method helped to assess the processes and phenomena of the national grain logistics market that directly affect it. The systematic approach helped to formulate the essence of the stated problem and choose ways to solve it. The analysis method was employed to substantiate the key factors that contributed to the normalisation of trade logistics during the war. The monographic method was applied to determine the price gaps in the cost of storing grain crops at elevators in Ukraine. The tabular and graphical methods were used to illustrate the results of the study in the form of tables and figures. To determine the cause-and-effect relationships in the Ukrainian grain logistics market, which involves identifying current trends in the development of this market, as well as challenges and dangers, a comparative analysis of indicators of grain cargo transportation by rail, the cost of internal and international road transportation of grain, the availability of elevator capacities and exports of major types of grain crops in the pre-war and war periods was used. The deductive method was employed to substantiate the risks that may hinder the development of infrastructure and the restoration of logistics chains in the future.

The key stages of the study included the analysis and systematisation of research by scientists from around the world on the development of the grain logistics market. A study of the current state of the grain logistics market in Ukraine, including substantiation of the indicators of grain rail transport when traffic through the "Ukrainian sea corridor" was accelerating (2023-2024), identification of significant problems with the growth of grain transportation tariffs and the cost of storing grain at elevators, as well as an assessment of available port capacities. The study analysed grain exports abroad by sea, rail, and road. The volume of losses of grain storage capacities was determined, as well as their recovery from the beginning of 2022 to 2024. The initiative between Ukraine and the European Union, which simplified the import and export of agricultural products, was substantiated. An algorithm of actions for the further development of the agricultural sector infrastructure after the end of the war and its reconstruction was proposed.

► Results and discussion

Ukraine has a well-developed transport and logistics infrastructure and a strong agricultural sector, which is why M. Kovalova (2024) noted that these features of Ukraine

contributed to the competitiveness of national companies in the international market. Before the war, Ukrainian agribusiness was focused on large warehouses and expensive modern automation systems, as scaling provided higher efficiency. N. Vasylytsiv (2023) addressed the fact that these solutions did not work at all when enemy missiles hit the warehouses of companies. Therefore, reliability became much more significant than efficiency. According to the researcher, in the current military conditions, Ukrainian logistics business participants adapted and transformed their logistics processes, including optimising logistics routes, cooperation with international partners, considering risks and focusing on processes that require them.

O. Penkova & A. Kharenko (2023) identified the positive influence of marketing and sales logistics during military operations on the prospects for growth in grain sales in European markets during the post-war recovery. The implementation of the proposed measures will enable Ukrainian exporters to find their niche in these markets and restore the export potential of grains and oilseeds to the markets of Africa and Asia. The hostilities also contributed to the emergence of such a negative phenomenon as illegal grain supply chains. J.El Baz *et al.* (2025) were the first to investigate the mechanism of fraudulent supply chains and supply chains of looted grain. O. Zerkina *et al.* (2022) proposed a structural model of institutional support for the reproductive logistics of the grain market, which is focused on the integration of its 'shadow' elements into the sphere of regulated supply chains and the fair redistribution of added value between their links.

Cargo is transported in Ukraine through the internal transport network, which includes roads, railways, inland river routes, and coastal sea routes without calling at foreign ports. The longest road network is the motorway network, with a length of 169.5 thsd km. Rail transport accounts for the bulk of grain shipments, with road transport also playing an essential role, as well as other modes such as water and river transport. An analysis of the structure of internal grain transportation shows that rail transport accounts for over 60% of all shipments, road transport accounts for 35%, and other modes of transport account for 5%. The length of railway tracks in operation is about 22 thsd km, including about 10 thsd km of electrified tracks. The monthly dynamics of grain cargo of JSC Ukrainian Railways reflects the modification of the logistics capabilities of grain exports after Russia's full-scale invasion and correlates with the capabilities of existing export routes, particularly through the ports of Greater Odesa (Fig. 1). In January-April 2024, the high volumes of grain transportation by rail correlated with the maximum exports abroad in February-May via the Ukrainian sea corridor, when grain shipments each month were within 3.5-4.0 million tonnes. The significant performance of grain rail transport in early 2024 was a continuation of the trend that began in November 2023, when the movement of grain cargo through the Ukrainian sea corridor was accelerating. It was found that in 2024, over 100,000 road carriers were engaged in internal transportation services. In 2024, the tariffs for road transport of grain crops increased by 1.3 times compared to 2022 and amounted to UAH 4.2 per t/km. As for international road transportation in Europe, the cost of grain carriage by grain carriers ranged

from EUR 80 to 200 per tonne, and grain transportation by tents – from EUR 1.5 to 4.0 per tonne. The cost of procurement services provided by the state-owned company – branches of the State Food and Grain Company of Ukraine is presented in Table 1. For agricultural enterprises from

different regions of Ukraine, services for receiving, drying, cleaning, and shipping grain crops in 2024/2025 increased by 1.3 times compared to 2022/2023 marketing years. This was caused by greater prices for petrol and diesel fuel, as well as increased wages, depreciation, and other factors.

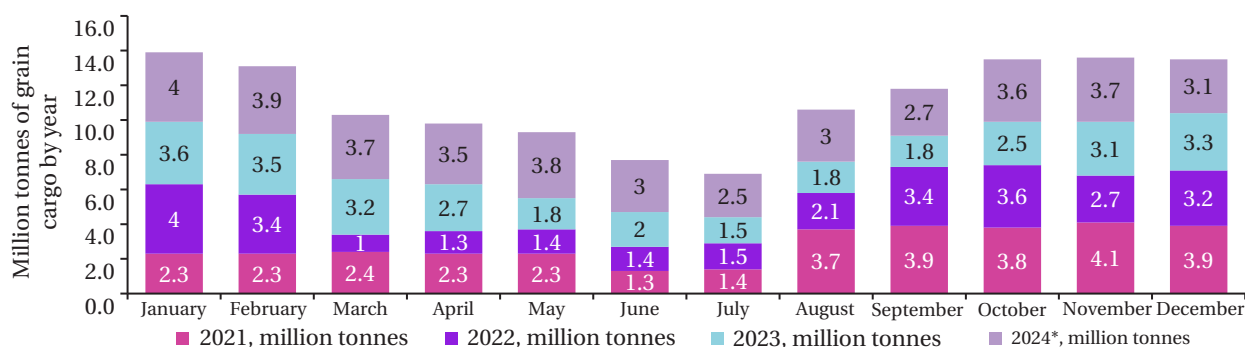


Figure 1. Monthly dynamics of grain transportation by JSC Ukrainian Railways, 2021-2024

Notes: the data in the chart for November-December 2024 are estimated

Source: built based on data from Grain transportation by rail in January-September 2024 reached an absolute record for the years of Ukraine's independence (2024)

Table 1. The cost of procurement services of the branches of the Joint Stock Company "State Food and Grain Company of Ukraine" for the 2024/2025 marketing year, UAH (including VAT)

Region	Delivery		Drying, UAH/t-%	Cleaning, UAH/t-%	Storage, UAH/t/day	Consignment	
	Automotive, UAH/t	Railway, UAH/t				Automotive, UAH/t	Railway, UAH/t
Cereal crops							
Northern	24-29	29	88-110	34-40	99-115	150-200	150-200
Southern	13-32	-	120-164	30	97-112	181-198	203
Eastern	28	-	146-180	21-31	74-117	190-210	190-210
Central	17-36	17-64	105-150	22-42	101-115	165-221	167-221
Western	26	53	120	28	119	189	219

Source: calculated based on data from Cost of procurement services for the 2024/2025 marketing year (n.d.)

Due to the risks posed by the war, most agricultural producers from the frontline areas are transporting grain for storage to elevators in central Ukraine to avoid losing their crops and to wait for prices to rise and sell their products at more favourable prices later. The appreciation of the USD to 41 UAH per 1 USD led to an increase in the cost of grain storage to an average of 107 UAH/t/day. During the period of martial law, the grain business adapted to the conditions and is gradually restoring damaged property, expanding existing facilities and building new ones. This was happening even in the regions bordering the enemy. Over 2023-2024, 1.9 million tonnes of elevator

capacity was built in the regions of Ukraine, including transshipment terminals. By region, the largest increase in capacity over the relevant period was in Khmelnytskyi – 300 thousand tonnes, Chernihiv and Poltava – 240 thousand tonnes each, Vinnytsia – 230 thousand tonnes, Volyn – 192 thousand tonnes, and Ternopil – 170 thousand tonnes. As of March 2024, the total elevator capacity of Ukraine's regions was approximately 41.4 million tonnes. However, despite a certain degree of restoration of elevator capacities, only Poltava, Zakarpattia, Odesa, and Mykolaiv regions were fully provided with grain storage facilities with the relevant storage capacity (Table 2).

Table 2. Elevator capacities by region of Ukraine

Region	Number of granaries (as of March 2024)	Total grain storage capacity (as of March 2024), thousand tonnes	Grain storage capacity increased, decreased (+/-) compared to 2022 to March 2024, thousand tonnes	Gross harvest of grains and pulses in weight after processing in 2023, thousand tonnes
Western regions of Ukraine				
Chernivtsi	11	≈264	+30	755
Ivano-Frankivsk	15	580	+35	881
Zakarpattia	7	≈700	+20	308
Lviv	42	1,200	+85	1,771
Ternopil	56	2,000	+170	2,856

Table 2, Continued

Region	Number of granaries (as of March 2024)	Total grain storage capacity (as of March 2024), thousand tonnes	Grain storage capacity increased, decreased (+;-) compared to 2022 to March 2024, thousand tonnes	Gross harvest of grains and pulses in weight after processing in 2023, thousand tonnes
Volyn	33	1,100	+192	1,372
Rivne	25	1,100	+73	1,270
Northern regions of Ukraine				
Zhytomyr	52	1,400	+50	2,418
Kyiv	≈70	2,800	+40	3,783
Chernihiv	≈75	3,300	+240	4,900
Sumy	≈49	2,600	-31	3,574
Central regions of Ukraine				
Cherkasy	67	2,800	+90	4,475
Khmelnyskyi	75	3,400	+300	3,700
Vynnytsia	104	4,400	+230	4,992
Kirovohrad	92	3,600	+50	3,992
Poltava	107	5,500	+240	5,277
Eastern regions of Ukraine				
Kharkiv	≈64	2,200	-490	2,466
Donetsk	-	-	-	-
Luhansk	-	-	-	-
Southern regions of Ukraine				
Dnipropetrovsk	90	3,000	-101	3,397
Mykolaiv	≈60	3,500	+10	2,413
Odesa	≈90	5,100	+50	4,048
Kherson	-	-	-	-
Zaporizhzhia	-	-	-	383
Total	≈1,184	≈41,400	1905	59,031

Notes: information on the occupied areas is not available due to the war

Source: calculated based on data from the State Statistics Service of Ukraine (n.d.) and from the website Elevatorist.com (Grain storage capacities..., 2024)

T. Luchnikova *et al.* (2023) investigated the problems of losses incurred by grain exports caused by the blocking of Ukrainian seaports under martial law, as well as the restoration of the flow of grain crops with the help of international partners and the professionalism of the grain logistics market. The researchers noted that despite the closure of the grain corridor and the clash of interests with Poland, which was quickly resolved, in the future Ukraine will manage to strengthen new logistics routes for grain exports. Therefore, the claim of O. Bodnar *et al.* (2024) that the hostilities caused a collapse in food exports appears to be debatable and exaggerated.

Russia's full-scale war against Ukraine led to the blockade of the Black and Azov Seas ports by the aggressor country, and therefore traders were forced to sell grain abroad via land and river routes to European countries with subsequent transshipment in European ports of the Black and Baltic Seas. The capacity of land and river crossings is severely limited. Specifically, Ukraine used to be capable of exporting 6-7 million tonnes per month via seaports, but in May 2022, exports via all road, rail, and river routes amounted to only 1.5 million tonnes. Between 1 July 2022 and 30 June 2023, Ukraine exported about 49.0 million tonnes of grain pulses, including 16.8 million

tonnes of wheat, 2.7 million tonnes of barley, and 29.1 million tonnes of maize (Ukraine exported almost..., 2023). O. Iatsenko (2024) substantiated the factors that contributed to the establishment of trade logistics in 2022:

1. To facilitate trade in agricultural products in times of war, on 22 July 2022, Ukraine signed the Black Sea Grain Initiative with the United Nations and the Republic of Turkey. Within the framework of this initiative, from August 2022 to March 2023, over 25 million tonnes of Ukrainian grain were exported.

2. To support the export logistics of grain in the absence of stable alternative routes and the sea blockade, Ukraine and the European Union signed the Agreement on Liberalisation of Road Freight Transport, which supports Ukraine in the field of transport, or 'transport visa-free regime'.

3. Construction of new checkpoints for road and rail transport and expansion of the capacity of existing checkpoints.

4. Increase of the capacity of the port infrastructure on the Danube.

In 2024, Ukraine had enough port capacities to cover all its export needs. Grain crops were exported from the ports of Greater Odesa – Chornomorsk, Pivdennyi, Odesa, as well as from ports on the Danube (Table 3).

Table 3. Total volumes of grain cargo transported by main types of traffic, million tonnes

Connection type	Year			
	2021	2022	2023	2024*
Transported in total, including	33.7	28.9	30.6	40.5
export, including	29.3	22.6	22.7	34.7
ports, including	28.7	15.1	14.3	29.5
Odesa	21.2	12.7	13.1	28.2
Danube	0.002	0.8	1.2	1.3
other ports	7.4	1.5	0	0.0
Border crossings	0.59	7.4	8.4	5.2
import	0.2	0.1	0.03	0.01
transit	0.6	0.5	0.4	0.5

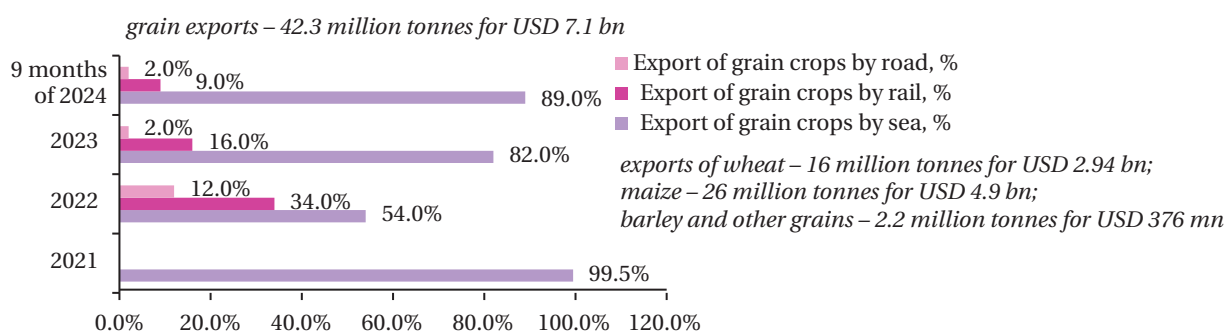
Notes: *Annual data for 2024 – estimated

Source: calculated based on data from Valery Tkachov: Logistical possibilities of grain export by rail in 2023-2024 (2024)

In the first 10 months of 2024, 38.9% more (33.7 million tonnes) was transported by rail compared to the corresponding 10-month period of 2023 (24.3 million tonnes). During the same analysed period, exports totalled 28.9 million tonnes, an increase of 64.3% compared to the first ten months of 2023. It was found that these figures were the greatest for the entire period under study. In 2024, the total volume of grain transportation by rail could reach 40.5 million tonnes. The opening of the 'sea corridor' in August 2023 had a massive positive impact on the opportunities for exporters of grain and other cargoes. The operation of the corridor has largely enabled the year-end increase in cargo transshipment in Ukrainian ports by 5% year-on-year (to 62 million tonnes) (A record 8 million..., 2024). The study substantiated the key factors influencing the volumes of transportation, namely: the shift in the timing of the 2023

harvest exports to the first half of 2024; the war caused a shortage of drivers, the primary reason being mobilisation measures within the country, which prompted farmers to reorient their cargoes from road to rail; and the absence of logistical restrictions on grain exports through the ports of Greater Odesa and western border crossings.

Grain cargo is transported to Ukrainian sea elevators by road and rail and then transhipped to special vessels. Containers with a capacity of 18-25 tonnes are suitable for small batches of grain, which are loaded at the place of production or purchase, sealed and delivered to ports. In total, in 9 months of 2024, Ukraine exported USD 7.1 bn worth of grain cargo, or more than 42 million tonnes (Exports of Ukrainian..., 2024). The resumption of maritime traffic resulted in 89% of agricultural products being exported by sea, 9% by rail, and only 2% by road (Fig. 2).

**Figure 2.** Grain exports by various modes of transport, 2021-2023 and 9 months of 2024

Source: calculated by the authors of this study based on data from Agricultural exports-2023: How much and where were grains and oils sold (2024) and Exports of Ukrainian agricultural products have increased significantly compared to last year (2024)

For comparison, in 2023, 82% of grain crops were exported by sea, 16% – by rail, and 2% – by road. The main buyers of wheat were Spain, the Republic of Turkey, and Romania. Accordingly, they accounted for 23%, 15%, and 14% of total exports of this crop. The main buyers of maize were the People's Republic of China, with an export share of about 22%, Spain – 13.7%, and Romania – 11.5%. Ukrainian barley was bought by the Republic of Turkey, the People's Republic of China, and Spain, and sorghum by Romania, Italy, and Poland (Agricultural exports-2023..., 2024).

Ukraine exported 33.0 million tonnes of grains and pulses since the beginning of 2024/25 marketing year as

of 4 April 2025. In terms of crops, since the beginning of the current season, Ukraine has exported 13.3 million tonnes of wheat, 2.2 million tonnes of barley, 17.1 million tonnes of maize, and 10.8 thousand tonnes of rye (Ministry of Agrarian Policy and Food of Ukraine, 2025). It is also worth noting the largest companies selling grain grown in Ukraine abroad: Kernel, French grain trader Louis Dreyfus, US agricultural companies Cargill and Archer Daniels Midland, the largest Ukrainian agricultural producers of grain crops Nibulon and Agroprosperis, as well as Swiss and Chinese companies Viterra and Cofco International.

The situation with imports is somewhat different. Specifically, 80% of agricultural products are imported to Ukraine by road, 18% – by sea, and only 2% – by rail. The key reason for this is that imports come from European countries, unlike exports, where goods are delivered all over the world. Ukraine's agricultural sector ensures a stable supply of products to foreign markets and meets internal needs through imports. The EU-Ukraine Solidarity Initiative, which is a lifeline for the Ukrainian economy, played a prominent role in this process. The primary goal of the initiative is to improve transport links between Ukraine and the European Union, including the development of alternative logistics routes by rail, road, and inland waterways. In this case, it is advisable to calculate a fuzzy model and create conditions for the use of alternative logistics chains in the process of grain delivery (Medvediev *et al.*, 2024). Within the framework of the initiative, the European Union allocated EUR 7 bn for leading infrastructure projects, allowing Ukrainian and Moldovan unions to take part; in 2023, the EU financed the improvement of infrastructure connections with Ukraine in the energy, digital, and transport sectors. In May 2023, EUR 250 million was invested to improve transport links between Ukraine, Moldova, and the European Union.

In times of war, it is adequate to use the experience of intermodal transport. C.H.F. de Faria *et al.* (2024)

employed a simulation-optimisation approach to planning an intermodal grain export chain through the collaboration of road freight transport, as well as rail and sea modes. M.G.M. Peixoto *et al.* (2022) also studied the efficiency of intermodal logistics, specifically intermodal terminals, and found that the best operational performance of their work can be ensured by using their structure and available resource potential. In 2022-2023, EUR 226 million was allocated to improve the logistics of motorways between Ukraine and the Republic of Moldova. Over the years, logistics routes with the Republic of Poland, Romania, and Germany were markedly improved, with an additional EUR 240 mn allocated for development. New agreements on road transport between the European Union, Ukraine, and Moldova will significantly increase the number of road transports to Western European countries. The rail links between the EU and Ukraine are the first step in connecting the European gauge tracks from Krakow (Poland) to Lviv (Ukraine) and from Iași (Romania) to Chisinau (Moldova). This lays the groundwork for improved logistics for rail freight in the coming years and increased freight traffic to the west and south. In 2022-2024, grain logistics losses will amount to more than USD 25 bn, 89% of which will come from losses due to the reorientation of logistics flows caused by the blocking of Black Sea ports (Table 4).

Table 4. Estimation of losses, potential risks, and algorithm of actions of grain logistics entities to restore infrastructure

No.	Element	Period	USD bn
Losses			
1	Blocking of Black Sea ports and reorienting of logistics flows	2022-2024	22.5
2	Lower grain prices caused by deteriorating market conditions	2022-2024	1.5
3	Destruction, damage, and loss of grain storage facilities due to occupation	2022-2024	1.3
Potential risks			
1	Loss of logistics facilities and disruption of logistics chains due to the spread of hostilities to new territories	period of hostilities	–
2	Insufficient state funding for logistics infrastructure restoration projects and difficult access to bank loans	during and after hostilities	–
3	Deterioration of the investment climate, imperfect legal protection of investment activities, challenges in doing business, high tax burden	during and after hostilities	–
Areas and projects of restoration			
1	Relocation of some logistics facilities to the western regions of Ukraine (transshipment hubs and cross-border terminals)	period of hostilities	2.3
2	Funding for the development of river logistics infrastructure and the creation of new routes for export and internal movement of agricultural products	during and after hostilities	
3	Creation of a railway transport corridor to the nearest Baltic ports through the construction of wide gauge sections	during and after hostilities	
4	Compensation for damages to grain terminals in the Black Sea ports due to blocking and damage	after hostilities	4

Source: developed by the authors of this study based on data from O. Zakharchuk *et al.* (2023)

The identified volumes of losses and potential risks during the period of instability helped shape the areas and costs of projects to restore logistics infrastructure and optimise cargo flows. Specifically, the relocation of some logistics infrastructure facilities, the development of river logistics, and the construction of a railway corridor to European ports are promising areas. The estimated cost of these projects is USD 2.3 billion. To compensate for the damage to the port grain infrastructure, the required funding should amount to about USD 4 billion.

► Conclusions

In 2024, there were no logistical restrictions for grain exports by rail, and grain was transported to the ports of Greater Odesa, to the western border crossings, and to the Danube ports. This year saw an increase in internal road transport of grain cargoes to UAH 4.2 per t/km, the price of international road transport in Europe ranged from EUR 80 to 200 per tonne, and the price of grain transport by tents from EUR 1.5 to 4.0 per tonne. It was found that due to the war, most agricultural producers from the frontline areas

exported grain for storage to elevators in central Ukraine not to lose their harvest, as well as to wait for higher prices and later sell their products at a more favourable price. The rise in the USD in 2024 to UAH 41 per 1 USD led to an average increase in the cost of grain storage to 107 UAH/t/day.

In 2023-2024, Ukraine built 1.9 million tonnes of elevator capacity, including transshipment terminals. As of the beginning of 2024, the total elevator capacities of the regions of Ukraine amounted to approximately 41.4 million tonnes, and their partial restoration by March of this year contributed to the provision of grain storage facilities with the corresponding storage capacity in full in only 4 regions of Ukraine – Poltava, Zakarpattia, Odesa, and Mykolaiv. The study identified the factors influencing the volume of grain cargo transportation by rail, namely: the shift in the timing of grain exports from 2023 to the first six months of next year; mobilisation measures related to the war prompted agricultural producers to change the transportation of grain cargo from road to rail; and the absence of logistical restrictions on grain exports abroad. It was substantiated that the resumption of maritime traffic was the primary reason 89% of total grain exports were carried

out by sea in 2024. In turn, exporters transported 9% of grain cargo by rail, and only 2% by road. As for imports, the situation was quite the opposite: 80% of imported agricultural products were transported by road, 18% – by sea, and 2% – by rail. This was mainly conditioned by imports from European countries, as opposed to exports, where goods are shipped all over the world. In the future, an algorithm of actions for further development of the agricultural sector infrastructure during and after the end of the war and its reconstruction is proposed, which would consider the key risks of further escalation, losses calculated as of the end of 2024, the primary tasks and the necessary funds for their implementation.

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Розвиток зернової логістики в Україні

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► **Анотація.** В сучасних умовах з'являються нові небезпеки, які впливають на поточне становище зернової логістики в Україні та яким необхідно протидіяти, щоб нівелювати їхній несприятливий вплив. Метою статті було дослідження сучасних тенденцій на ринку логістики зернових та виявлення нових викликів і загроз, а також формування алгоритму дій для розвитку інфраструктури агросектору під час та після закінчення війни. При розгляді проблем та завдань дослідження авторами статті застосовувались наукові методи, а саме: діалектичний, системний підхід, порівняльний аналіз, табличний та графічний, монографічний, а також дедуктивний, які визначають спосіб і послідовність рішення поставлених завдань. У роботі проаналізовано щомісячну динаміку транспортування зернових вантажів залізницею за 2021-2024 рр. Досліджено тарифи на внутрішні та міжнародні перевезення урожаю зернових культур автомобільним транспортом, а також вартість послуг заготівельної діяльності філій Акціонерного товариства «Державно продовольчо-зернової корпорації України». Встановлено, що у період військового стану зерновий бізнес адаптувався до умов, які виникли та поступово відновлює пошкоджене майно, розширює наявні потужності, а також будує нові. Простежено, що за 2023-2024 рр. в областях України побудували 1,9 млн тонн елеваторних потужностей разом з місткостями перевантажувальних терміналів, а загальні елеваторні потужності на початок 2024 року складають приблизно 41,4 млн тонн. Обґрунтовано основні фактори, які сприяли нормалізації торговельної логістики у 2022 р. Проаналізовано експорт та імпорт зернових культур різними видами транспорту, а також розглянуто основні країни-покупці та найбільші компанії експортери українських зернових. В дослідженні науково обґрунтовано ініціативу «Шляхи солідарності Україна – ЄС». Зроблене аргументоване обґрунтування алгоритму дій для подальшого розвитку інфраструктури агросектору під час та після закінчення війни щодо його відбудови. Використання викладених у цьому дослідженні пропозицій дозволить краще оцінювати стан зернової логістики України в умовах війни та повоєнної відбудови. Пропозиції та практичні рекомендації дослідження можуть бути корисними працівникам органів державного управління, фермерам, а також іншими агровиробниками, тому що можуть бути застосовані при розробці належних програм та заходів, направлених на підтримку розвитку зернової логістики в Україні

► **Ключові слова:** транспортні перевезення; зберігання продукції; залізниця; елеваторні потужності; порти Великої Одеси; алгоритм дій