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### **INTERNATIONAL GRAIN SUPPLY CHAINS UNDER MARTIAL ARTS**

*Nowadays Ukraine in all spheres has been transformed due to the difficult conditions of martial law, in which the country has been for a long time. In particular, such changes concern logistics, namely the destruction of the usual international cargo supply chains. Logistics companies were forced to quickly respond to hybrid threats and develop new alternative cargo supply chains, in particular grain, change delivery routes using alternative modes of transport and find new directions for managing such chains. Given the above research, the issue of the functioning of international supply chains is relevant and timely and will help to identify gaps in this issue.*

*The research is based on the hypothesis that hostilities in Ukraine have affected the geography of exports and imports, including products of the agro-industrial complex. The methods of elementary theoretical analysis and synthesis, deduction, economic and statistical methods, in particular grouping and graphics, were used, thanks to which the results of the research are visually presented.*

*The challenges for grain cargo supply chains under martial law are outlined and a list of tools for overcoming these challenges is provided. An analysis of adaptation to the challenges of martial law was conducted; in particular, the functioning of the "grain and Ukrainian corridors" under current conditions was investigated. The geography of grain exports was studied, a list of main partners before martial law and in war conditions was determined. The impact of changes in the geography of grain exports on world food security was determined.*

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### **МІЖНАРОДНІ ЛАНЦЮГИ ПОСТАЧАННЯ ЗЕРНОВИХ ВАНТАЖІВ В УМОВАХ ВОЄННОГО СТАНУ**

*Сьогодення України трансформоване через важкі умови воєнного стану, в якому країна перебуває вже тривалий час. Зокрема ці зміни пов'язані з руйнуванням звичних міжнародних ланцюгів постачання вантажів. Логістичні компанії були змушені швидко реагувати на гібридні загрози та розробляти нові альтернативні ланцюги постачання зернових вантажів, змінювати шляхи доставки, використовуючи альтернативні види транспорту, а також знаходити нові напрями управління такими ланцюгами. Відтак аналіз функціонування міжнародних ланцюгів постачання є надзвичайно актуальним і своєчасним, оскільки завдяки цьому можна виявити прогалини в цій сфері. Невчасне вирішення проблеми може загрожувати продовольчій безпеці багатьох країн.*

*В основу дослідження покладено гіпотезу, що бойові дії на території України вплинули на географію експорту та імпорту, зокрема продукції агропромислового комплексу. Використано методи елементарно-теоретичного аналізу та синтезу, дедукції, а також економіко-статистичні, групування та графічне представлення результатів дослідження.*

*Окреслено виклики для ланцюгів постачання вантажів зернових в умовах воєнного стану та визначено перелік інструментів подолання цих викликів. Проведено аналіз адаптації до умов воєнного стану, зокрема досліджено функціонування "зернового та українського коридорів" у нинішніх умовах. Досліджено географію експорту зернових, надано перелік основних партнерів до воєнного стану та в умовах війни. Визначено вплив зміни географії експорту зернових на продовольчу безпеку світу.*



*As a result of the research, the author concluded that given that the main supply chain through the Black Sea was not fully used in general, Ukraine has today retained its leading position in grain exports and has even been able to expand the geography of supplies.*

*Keywords:* supply chains, grain cargo, martial law, export.

*У результаті проведеного дослідження зроблено висновок, що, попри обмежене використання основного ланцюга постачання через Чорне море, Україна зберегла свої лідируючі позиції в експорті зернових і навіть змогла розширити географія постачань.*

*Ключові слова:* ланцюги постачання, зернові вантажі, воєнний стан, експорт.

JEL Classification: F14, F40, Q17, R49.

## Introduction

The devastating consequences of the Russian Federation's aggression against Ukraine are felt in all spheres of social and economic life. One of the important aspects of this general situation is the destruction of international cargo supply chains, which has become a threat to the food security not only of Ukraine, but also of many countries for which Ukraine is one of the largest grain exporters. Logistics companies were forced to quickly respond to hybrid threats, develop new alternative cargo supply chains, in particular grain, change delivery routes using alternative modes of transport, and also look for new directions for managing such chains. Therefore, research into the functioning of international cargo supply chains is extremely relevant.

A number of scientists have studied the problem of the formation and functioning of supply chains under martial law. In particular, the logistics of oilseed crops in Ukraine and the main directions of its improvement were studied by Shiryaeva and Sokolov (2024), concluding that quick commercial and logistical solutions are needed, as well as an operational response to the constantly changing situation. Gusenko and Bomchak (2023) analyzed the current state and dynamics of grain exports in Ukraine in the context of the complexity of international logistics.

Scientists Sushchenko and Ilchenko (2023) identified the main problems associated with the formation of supply chains during the war in Ukraine and provided recommendations for minimizing risks in the logistics industry. The authors proved that the adaptation of supply chains in martial law occurs through a rethinking of business processes, for which it is necessary to constantly study the processes of ordering and supplying goods.

Migai (2024) investigated the impact of war on macroeconomic indicators of the functioning of the economy and assessed the mutual influence of inflationary processes and logistics chains, providing a justification for the optimal directions of their organization in conditions of high risk. Sopotsko (2022) analyzed the current state of food supply chains and the impact of the war in Ukraine on logistics activities, providing some recommendations for managing such chains.

Nechporuk et al. (2022) investigated the throughput capacity of grain exports by rail. In their work, the authors identified the problems of managing agricultural supply chains and proposed ways to solve these problems in conditions of war.

Kryveshchenko et al. (2024) in their scientific article identified the directions of optimizing logistics chains in the context of increasing global crises and proved that optimizing supply chains in conditions of global crises is a complex process that requires the use of modern technologies.

Volokhova I. and Volokhov V. (2023) systematized the main challenges and directions of work of the logistics front in his publication. The authors identified the fuel crisis, the problem of military logistics, grain transportation, and border crossing points, bureaucratic apparatus, and the lack of a development strategy as the main challenges of today. Scientists proposed directions for solving these problems.

Luchnikova, Kovalenko and Sholom (2023) conducted a study of the logistics processes of managing the supply chains of goods exports in Ukraine under martial law and proposed the main directions of such management. The authors proved that under the current crisis conditions of management, the greatest losses were suffered by the export of goods, especially grain, which is critical not only for the economy of Ukraine, but also for the well-being of the whole world.

The research results of the full-scale russian invasion impact on the world trade in oilseed crops are considered in the work (Soojung et al., 2023). It was determined that the russian-ukrainian war significantly affects the geography of grain exports, which has negative consequences for the economies of a number of countries around the world.

The aim of the research is to identify the main challenges for cargo supply chains under martial law and the impact of these challenges on international grain cargo supply chains under these conditions.

Overcoming the challenges of martial law for the effective management of international supply chains is impossible without a detailed analysis of the current state of grain exports, which emphasizes the relevance of this research. It is based on the hypothesis that the hostilities in Ukraine have affected the geography of exports and imports, including products of the agro-industrial complex. Untimely resolution of this problem may pose a threat to the food security of many countries.

The information basis of the research was the work of national and foreign scientists, data from the State Statistics Service of Ukraine, the Information and Analytical Agency "APK-Inform", the Ministry of Agrarian Policy and Food of Ukraine, the International Trade Center, as well as the results of research by the Center for Foreign Policy Studies.

During the analysis, the methods of elementary theoretical analysis and synthesis, deduction, economic and statistical methods, in particular grouping and graphics, were used, which made it possible to visually present the results of the research.

The main part of the article consists of three sections: the first considers the challenges for the grain export market in martial law conditions and provides a list of tools for overcoming these challenges. The second is devoted to the analysis of adaptation to these challenges, in particular the functioning of the "grain and Ukrainian corridors" in modern conditions.

The third section examines the geography of grain exports, identifies the main partners before the start of hostilities, and also assesses the impact of changes in the geography of grain exports on world food security.

### 1. Challenges for grain supply chains under martial law

The hostilities in Ukraine, which began in 2014 in the Donetsk and Luhansk regions and later escalated into a full-scale invasion on February 24, 2022, forced logistics companies to quickly adapt to serious challenges in the process of transporting and storing goods. This created the need for a rapid response to difficult conditions that affected not only the logistics sector, but also the economy as a whole (Telegin & Koval, 2023). In wartime, it is impossible to plan long-term storage of goods (grain), since grain stocks can be lost during an attack, and the deployment of a new storage facility takes about three months. Logistic activities are significantly complicated by checkpoints, numerous checks, and opaque movement rules during curfews.

The consequences of war for logistics companies include specific challenges (*Figure 1*), which directly affect the change in the functioning of logistics flows.

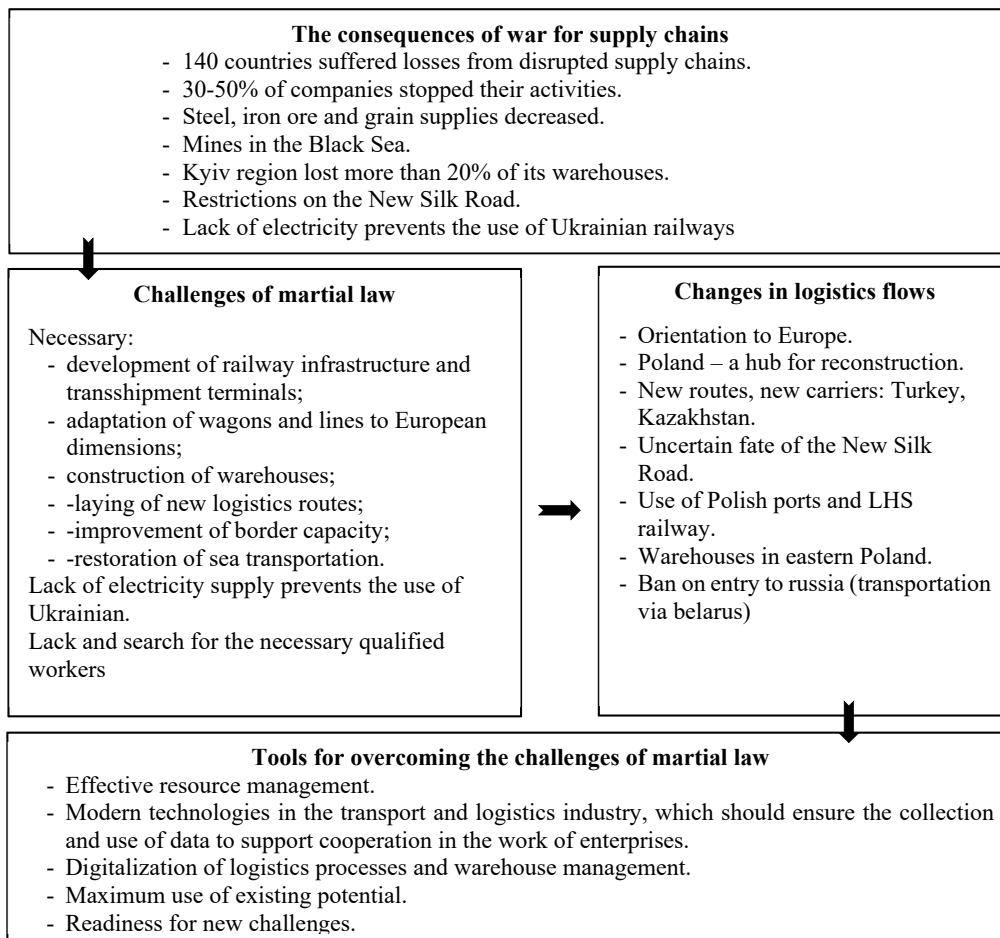


Figure 1. The biggest challenges for grain supply chains under martial law

Source: compiled by the author according to (CargoON, 2024).

To overcome the current complex challenges in logistics processes, it is necessary to coordinate all parts of their management, supported by the use of innovative IT systems that facilitate control and allow for further optimization.

## **2. Functioning of the "grain and Ukrainian corridors" in the context of war**

Export routes, including grain cargo, developed over decades and provided the Ukrainian economy with significant foreign exchange earnings. Products of the agro-industrial complex were exported to various countries and the world. The Russian-Ukrainian war significantly disrupted export routes. In 2022, the ports of Berdyansk, Mariupol, Mykolaiv, Skadovsk and Kherson were under the full control of the invaders, which paralyzed the work of the ports of Great Odessa and Dunayske. Disruptions in the export of grain cargo caused a significant shortage of basic food products in the countries of Africa and Asia. The difficult task of transporting grain cargo stored in warehouses exacerbated the global food crisis. There was an urgent need to create alternative logistics routes.

International institutions and heads of state joined the global problem, which Russia had joined by then (Sira & Filippova, 2024, April 24). The problem was partially resolved by signing the so-called "grain agreement" or the Black Sea Grain Initiative, the main goal of which was to unblock three ports (Odessa, Chornomorsky, and Yuzhny) for the export of grain and other products of the agro-industrial complex. The agreement (the so-called Black Sea Grain Initiative) was signed on July 22, 2022 in Istanbul by the Minister of Infrastructure of Ukraine O. Kubrakov and the Minister of Defense of Russia S. Shoigu, with the UN and Turkey acting as guarantors. The first ship with Ukrainian grain was sent from the port in Odesa on August 1 (Luchnikova, Tarnovska & Vorobyov, 2023).

Grain corridors have become an important tool for restoring food supplies. Despite martial law, constant shelling, significant destruction of transport infrastructure, and the blocking of the "grain corridor" by Russia, Ukraine has remained the largest supplier of agricultural products. Thus, during the period of operation of the "grain corridor" from Ukraine, about 32.9 million tons of grain cargo and oil were exported, 1004 ships left Ukrainian ports with grain in difficult conditions to 45 countries of the world.

Therefore, grain corridors in wartime have become not only a matter of economic stability for Ukraine, but also an important element for ensuring food security throughout the world. The main grain cargoes that were supplied through this corridor are shown in *Figure 2*.

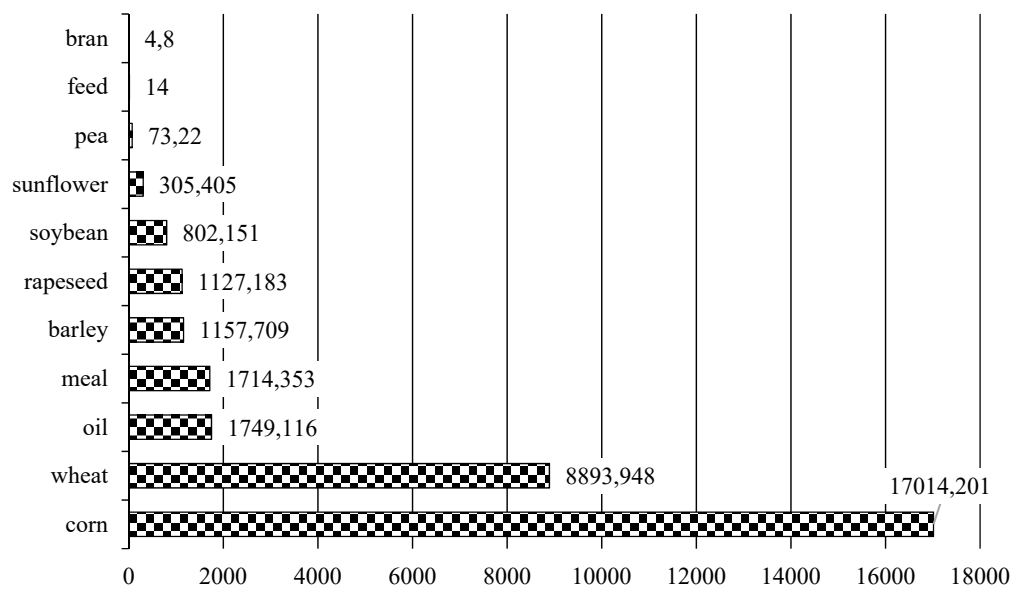


Figure 2. Export commodity structure of agricultural products by the "grain corridor" for the period of its operation in 2022–2023, thousand tons

Source: compiled by the author based on data from (APK-Inform, n. d.).

During the operation of the "grain corridor" (Figure 2), the export nomenclature was dominated by corn (51.8%), wheat (27.1%), and oil (5.3%). The main importing countries within the framework of the Black Sea Grain Initiative in 2022–2023 were China – 24.2%, Spain – 18.2%, Turkey – 9.9%, Italy – 6.3%, the Netherlands – 6%, Egypt – 4.7%, Bangladesh – 3.2%, and other countries – 27.5% (Bobrovtskyi et al., 2024).

The operation of the "grain corridor" ceased on July 16, 2023, with the termination of the agreement by Russia, so the work of the Black Sea Grain Initiative was blocked again.

To unblock ships that were stuck in Ukrainian ports on their way to Africa and Asia and resume the export of Ukrainian goods in August 2023, Ukraine proposed opening a so-called humanitarian corridor without Russia's participation. The temporary route, called the "Ukrainian Corridor", began operating on August 8, 2023, with the evacuation of blocked ships. As of November 20, 2024, 3,118 ships had passed through the "Ukrainian Corridor", and 83.5 million tons of cargo had been delivered from Ukrainian ports to 46 countries around the world, of which 55.6 million tons were grain.

Unlike the "grain corridor", the "Ukrainian Sea Corridor" provides not only agricultural products, so Ukraine has the opportunity to independently control exports (Ministry of Community and Territorial Development of Ukraine, 2024, August 16). Despite the difficult conditions of martial law and constant shelling of critical infrastructure, according to the results of 2023, Ukraine retained its leading positions in the world export of certain agricultural and food products (Table 1).

*Table 1*

The place of Ukraine in the world ranking of exporters in 2023

Commodity item	Position
Sunflower oil	1
Rapeseed	3
Sorghum	4
Walnuts	4
Corn	4
Sunflower	5
Barley	5
Rapeseed oil	6
Soybean	6
Wheat	6
Soybean oil	7
Poultry meat	7
Butter	9
Soybean meal	10
Sugar	21

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

It was possible to maintain such high positions in the world ranking of exporters thanks to the successful functioning of the "grain" and later the "Ukrainian" corridors, which became important for ensuring the functioning of international grain supply chains in the difficult conditions of martial law.

### 3. Countries – partners of Ukraine in grain exports

After the full-scale invasion, the geographical structure of agricultural exports changed (*Figure 3*).

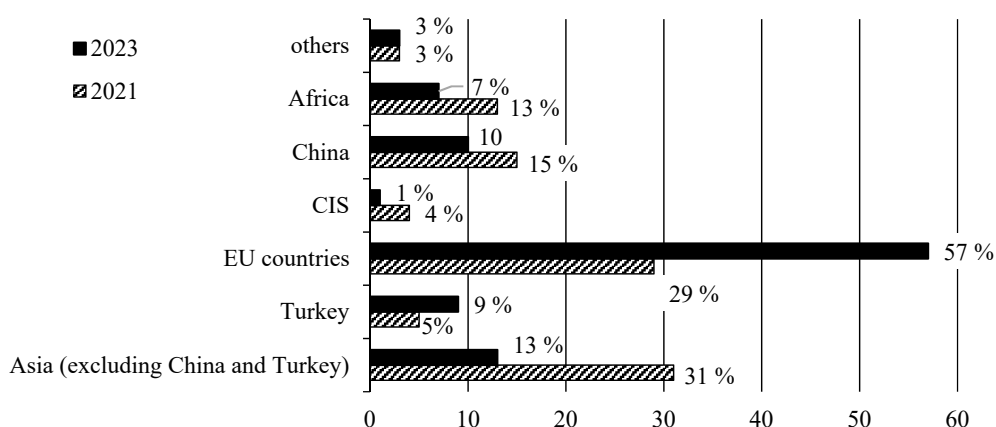


Figure 3. Geographical structure of agricultural exports from Ukraine in 2021 and 2023, %

*Source:* compiled by the author based on data from the International Trade Center (International Trade Center, n. d.).

As we can see from *Figure 3*, in 2023, the largest market for Ukrainian agricultural products, including grains, became the European Union, the share of which increased significantly compared to 2021. Such changes led primarily to the war-related destruction of the usual supply chains for these products. The market for Ukrainian food products to the EU includes countries such as Romania, Spain, the Netherlands, Italy, Germany, and Hungary. China remained the second place in 2023, although with a slightly smaller share in the total volume. The top three countries in recent years have invariably included Asian countries (excluding China and Turkey), although the share of exports to these countries in 2023 decreased by 18% compared to 2021 (Bobrovtskyi et al., 2024).

A more detailed geography of grain exports in 2023 compared to pre-war 2021 is presented in *Table 2*.

*Table 2*

Export dynamics of grains (grain processing products) from Ukraine to major markets in 2021, 2023, billion USD

Products	Period	Total amount	Main markets/volume		
Sunflower oil	2021	6.4	India/1.9	EU/1.9	China/0.9
	2023	5.0	EU/1	Turkey/0.8	China/0.5
Corn	2021	5.9	China/1.9	EU/1.8	Egypt/0.5
	2023	5	EU/2.9	China/1.1	Egypt/0.5
Wheat	2021	5.1	Egypt 0.9	Indonesia /0.7	Turkey/0.4
	2023	2.9	EU/1.5	Turkey/0.4	Egypt/0.2
Rapeseed	2021	1.7	EU/1.1	Pakistan/0.2	Great Britain /0.2
	2023	1.2	EU/1.1	Turkey/0.02	Great Britain /0.02
Barley	2021	1.3	China/0.7	Turkey/0.2	Saudi Arabia /0.1
	2023	0.4	EU/0.2	Turkey/0.08	China/0.07
Sunflower cake (meal)	2021	1.2	China/0.6	EU/0.3	belarus /0.1
	2023	0.9	EU/0.4	China/0.3	Turkey/0.04
Total	2021	27.7	EU/7.7	China/4.3	India/2
	2023	22	EU/12.5	China/2.2	Turkey/2

*Source:* compiled by the author based on data from (International Trade Center, n. d.).



Thus, in 2023, Ukraine exported only 21% less agro-industrial products than in 2021, which was a record year. In 2023, the largest share of exports was accounted for by grain crops (38%), fats and oils, prepared edible fats, waxes (26%), and seeds and fruits of oil plants (13%) (International Trade Center, n. d.).

Russia’s full-scale invasion of Ukraine has finally changed the geographical structure of exports by individual commodity items, in particular Ukrainian grain. The disruption of certain shipping routes has led to the fact that Ukrainian wheat exports are now more directed to the EU and less to Asian and African countries (*Figure 4*).

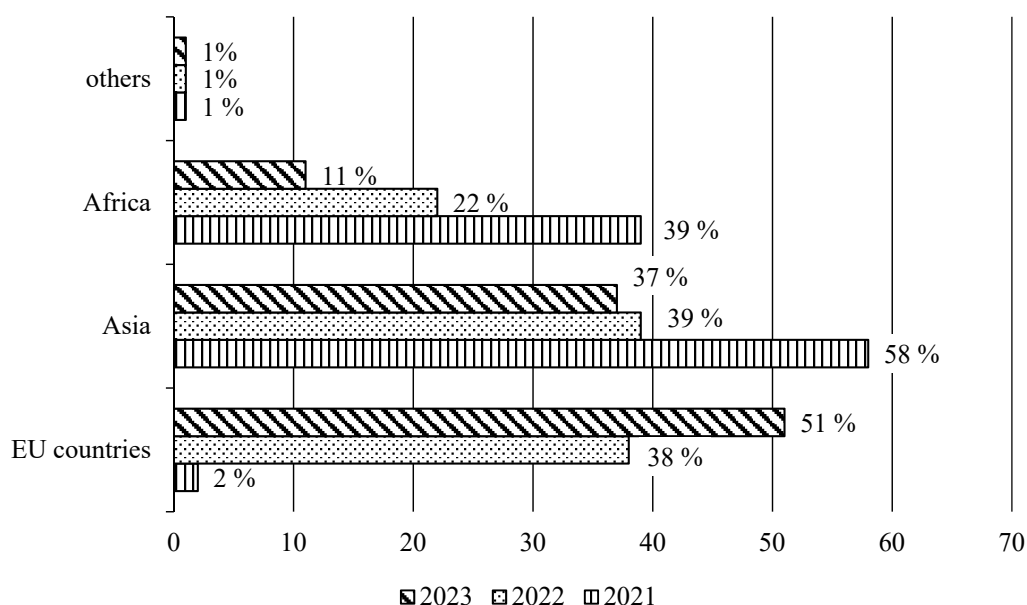


Figure 4. Geography of Ukrainian wheat exports by world regions in 2021–2023, %

Source: compiled by the author based on data from (International Trade Center, n. d.).

According to *Figure 4*, the share of exports to the EU has increased significantly since 2021, which is explained primarily by the impossibility of transporting cargo by the usual, well-established supply chains in wartime. At the same time, African countries experienced a significant decrease in wheat exports, although before the full-scale invasion of the Russian Federation into the territory of Ukraine, many countries in Asia and Africa counted on the import of Ukrainian wheat (Bobrovtskyi et al., 2024).

Assessing the importance of Ukrainian grain exports to a large number of developing countries, in particular in Asia and Africa, it should also be taken into account that, by ensuring the supply of raw materials and food products for production to these countries, Ukraine reduces their dependence on Russia and stabilizes world prices. For Ukraine, maintaining its export potential at a high level makes it possible to receive additional budget revenues, supporting the national economy in wartime.

## Conclusions

After Russia's full-scale invasion of Ukraine, national logistics companies faced challenges that negatively affected the functioning of international cargo supply chains, including grain. Therefore, the primary task was to establish international food supply chains. Russia's blockade of Ukrainian ports, constant shelling, and massive destruction of port infrastructure made it impossible to export grain and other cargo, which became one of the biggest challenges of the war. This situation threatened global food security, as Ukraine is one of its guarantors. Accordingly, the urgent problem of forming new alternative supply chains arose. Therefore, the research confirmed the hypothesis that the hostilities in Ukraine affected the geography of exports and imports, in particular products of the agro-industrial complex. Thus, the export share to the EU after the full-scale invasion of Ukraine by the Russian Federation significantly increased, which is explained primarily by the impossibility of transporting cargo using familiar, well-established supply chains in wartime. At the same time, African countries experienced a significant decrease in wheat exports, although until February 24, 2022, many Asian and African countries were counting on importing Ukrainian wheat.

The rapid response of the authorities within international allies, the successful actions of the Armed Forces of Ukraine, the Security Service of Ukraine and the State Security Service in the Black Sea made it possible to successfully exist first the "grain corridor", and then the "Ukrainian corridor" and other equally important projects. Thus, despite the fact that the main supply chain through the Black Sea was not fully used, Ukraine retained its leading position in grain exports and was even able to expand the geography of supplies. In the future, the main means of overcoming the challenges of martial law and effective management of grain logistics should also include productive resource management; the use of modern technologies in the transport and logistics industry; increased digitalization of logistics processes and warehouse management; readiness for new challenges, etc. Prospects for further scientific research include the development of a mechanism for managing international grain supply chains under martial law.

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**Conflict of interest:** The author declares that he/she has no financial or non-financial conflicts of interest in relation to this publication; has no relationships with governmental bodies, commercial or non-commercial organizations that could be interested in presenting this viewpoint. Given that the author works for an institution that is the publisher of the journal, which may give rise to a potential conflict or suspicion of bias, the final decision to publish this article (including the selection of reviewers and editors) was made by those members of the editorial board who are not affiliated with this institution.

The author did not receive direct funding for this research.

Mylnychuk, T. International grain supply chains under martial arts. *Scientia fructuosa*. 2025. № 1. P. 90–101. [https://doi.org/10.31617/1.2025\(159\)06](https://doi.org/10.31617/1.2025(159)06)

*Received by the editorial office 26.11.2024.*

*Accepted for printing 17.12.2024.*

*Published online 17.02.2025.*