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## PECULIARITIES OF INTERNATIONAL LOGISTICS OF AGRICULTURAL PRODUCTS IN A WAR ECONOMY

**Abstract.** *The agricultural sector is a vital food source for the entire planet. With population growth, the demand for food increases, emphasizing the need for sustainable development of agriculture to ensure sufficient volumes. Moreover, the agricultural sector is a significant component of many countries' gross domestic product (GDP), especially developing ones. Agriculture provides millions of jobs worldwide, especially in rural areas. The agricultural industry not only directly creates jobs but also stimulates employment in related fields such as transportation, logistics services, processing, and trade. Many countries, including Ukraine, are powerful exporters of agricultural products, ensuring a significant foreign currency inflow. The agricultural sector provides raw materials for numerous industries, including food, textile, pharmaceutical, and biofuel. In addition, agriculture is a platform for innovation, stimulating the development of advanced technologies such as precision farming, biotechnological solutions, automation, and uncrewed aerial vehicles. In a war economy, ensuring effective logistics of agricultural products requires significant efforts to adapt to new circumstances. The key success factors in such conditions are flexibility, rapid response to changing situations, and the ability to optimize logistics chains, considering the increased risks. Companies must actively explore alternative transportation routes, diversify supply sources, invest in innovative technological solutions, and use all available opportunities to adapt to new economic and security conditions. Adapting international logistics strategies in wartime requires flexibility, innovation, and close*

*cooperation between states, enterprises, and international institutions. Digital technologies and the development of partnerships are practical tools for minimizing logistics risks, ensuring food security, and ensuring the stability of supplies in unstable conditions. This reduces dependence on traditional logistics channels and increases the agricultural sector's resilience to crises.*

*Consequently, international logistics is an indispensable element of supply stability in the agricultural sector, as it ensures timeliness, optimizes costs, minimizes risks, and guarantees compliance with international quality standards. Effective international logistics strengthen global food security, making it possible to maintain stable supplies of agricultural products even in difficult situations and under sharp market fluctuations.*

**Keywords:** *logistics, logistics services, product logistics, agricultural sector, martial law.*

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## ОСОБЛИВОСТІ МІЖНАРОДНОЇ ЛОГІСТИКИ ПРОДУКТІВ АГРАРНОГО СЕКТОРУ ЗА УМОВ ВОЄННОЇ ЕКОНОМІКИ

**Анотація.** *Життєво важливе джерело їжі, аграрна сфера забезпечує продуктами харчування всю планету. Зі зростанням чисельності населення збільшується і попит на продовольство, що підкреслює необхідність стабільного розвитку сільського господарства для гарантування достатніх його обсягів. Більше того, аграрний сектор є вагомим складовим валового внутрішнього продукту (ВВП) багатьох держав, особливо тих, що розвиваються. Сільське господарство - це мільйони робочих місць по всьому світу, особливо у сільській місцевості. Аграрна галузь не тільки безпосередньо створює робочі місця, але й стимулює зайнятність у супутніх сферах, таких як транспортування, логістичні послуги, переробна промисловість та сфера торгівлі. Чимало країн, включаючи Україну, є*

потужними експортерами аграрної продукції, що забезпечує значний приплив валютних коштів. Аграрний сектор забезпечує сировинною базою численні галузі промисловості, зокрема харчову, легку, фармацевтичну та біопаливну. Крім того, сільське господарство є плацдармом для впровадження інновацій, що стимулює розвиток передових технологій, таких як прецизійне землеробство, біотехнологічні рішення, автоматизація та використання безпілотних літальних апаратів. В умовах воєнної економіки забезпечення ефективної логістики аграрної продукції потребує значних зусиль для адаптації до нових обставин. Ключовими факторами успіху в таких умовах є гнучкість, оперативне реагування на мінливу ситуацію та здатність до оптимізації логістичних ланцюжків з урахуванням підвищених ризиків. Компаніям необхідно активно досліджувати альтернативні транспортні маршрути, диверсифікувати джерела постачання, інвестувати в інноваційні технологічні рішення та використовувати всі доступні можливості для пристосування до нових економічних та безпекових умов. Адаптація стратегій міжнародної логістики в умовах воєнного часу вимагає гнучкості, впровадження інновацій та тісної взаємодії між державами, підприємствами та міжнародними інституціями. Використання цифрових технологій та розвиток партнерських ініціатив є ефективними інструментами для мінімізації логістичних ризиків, гарантування продовольчої безпеки та забезпечення стабільності поставок у нестабільних умовах. Це дає змогу зменшити залежність від традиційних логістичних каналів та підвищити стійкість аграрного сектора до кризових явищ. Отже, міжнародна логістика є незамінним елементом стабільності постачань в аграрному секторі, оскільки вона забезпечує своєчасність, оптимізує витрати, мінімізує ризики та гарантує відповідність міжнародним стандартам якості. Як наслідок, ефективна міжнародна логістика сприяє зміцненню глобальної продовольчої безпеки, даючи можливість підтримувати стабільні поставки сільськогосподарської продукції навіть у складних ситуаціях та за умов різких ринкових коливань.

**Ключові слова:** логістика, логістичні послуги, продуктова логістика, аграрний сектор, воєнний стан.

**Актуальність.** The agricultural sector, a cornerstone of the global economy, is not just a provider of food and raw materials for industry, but a key element of food security. Its significance can be appreciated from multiple angles: food security, employment, economic growth, and export potential. Its sustainable development not only enhances human well-being but also preserves natural resources and ensures the provision of future generations.

The agricultural sector is the primary food source for the world's population. Population growth increases the demand for food, making the sustainable development of the agricultural sector essential to ensure sufficient food supplies. It is also an important component of GDP in many countries, especially in developing economies. In some countries, the share of agriculture in GDP can reach 20-30 %, while in developed countries, this figure is lower due to the high level of mechanization and intensity of production.

The agricultural sector, a major employer, sustains millions of people worldwide, particularly in rural areas. It not only provides jobs but also supports employment in related industries such as transport, logistics, processing, and trade. Many countries, including Ukraine, are significant exporters of agricultural products, contributing to their foreign exchange earnings. The main export products, such as grain, soybeans, coffee, sugar, and oilseeds, are crucial elements of world trade. The developed agricultural sector of some countries can even provide food to other countries, thereby strengthening international trade.

**Мета статті:** To study the main challenges of international logistics of agricultural products in times of war, as well as methods of overcoming these difficulties; to provide theoretical justification and practical recommendations that may be useful for logistics companies, agricultural enterprises, governments, and international organizations.

**Аналіз останніх досліджень і публікацій.** The study of issues related to the functioning of the logistics industry is devoted to the works of several domestic scholars, including Bezugla L. S., Yurchenko N. I., Ilchenko T. V., Palchyk I. M., Volovyk D. V., Pavlova O. M., and Pavlov K. V. [1, 11].

At the same time, insufficient attention has been paid to the peculiarities of the logistics processes of agricultural products at the international level, which necessitated the conduct of this study.

**Постановка проблеми.** The agricultural sector supplies raw materials for many industrial sectors, including the food, textile, pharmaceutical, and biofuel industries. In addition, agriculture is an area of active innovation, with developments such as precision farming, biotechnology, automation, and drones. For instance, precision farming uses GPS technology to optimize field operations, while biotechnology has led to the development of disease-resistant crops. These new technologies increase production efficiency, improve product quality, reduce negative environmental impacts, and help adapt to climate change. Hence, the environmental impact of agriculture. At the same time, the agricultural sector supports the development of rural areas by promoting the preservation of traditions and culture

and providing infrastructure in rural areas.

**Вклад основного матеріалу.** Some countries, such as the United States, Canada, Brazil, Ukraine, and others, are major suppliers of agricultural products, including agricultural products, to the world market. Their stable agricultural productivity ensures global food security, as other countries can access food through imports. If agricultural exports from these countries are disrupted, there are serious risks to food security worldwide. Military conflicts significantly impact agricultural product production and delivery, causing instability, delays, and increased risks in the supply chain. Complications arise at all stages - from growing crops to transporting products to consumers.

International logistics, a linchpin in ensuring the stability of supply in the agricultural sector, spans the entire supply chain from production to the end consumer. With the global integration of markets and the burgeoning needs of the population, logistics has become a critical factor for the efficient functioning of the agricultural sector and global food security [4]. We have identified the main aspects of international logistics that are pivotal for the stability of supply in agriculture and have presented them in Tab.11.

Table 1 – Key aspects of international logistics in the agricultural sector

№	Aspect	Features	Inventory
1	Ensuring timely deliveries	Fast transportation of products with a limited shelf life. Optimization of routes and choice of transport.	Minimizes delays, which is important for the delivery of fresh products such as fruits, vegetables, dairy products, etc.
2	Optimize transportation costs	Effective planning of logistics operations. Reduced logistics costs.	It allows producers to compete in the global market, reduces the cost of goods for the end consumer and maintains price stability.
3	Access to markets and increase export potential	Opening of new markets, stable supply and increase of the country's export potential.	This is especially important for countries where the agricultural sector is the leading industry. It helps to ensure a stable supply of agricultural products on a global level.
4	Reducing risks and ensuring supply chain resilience	Reducing the risk of supply interruptions and rerouting routes in case of force majeure.	An extensive network of logistics routes allows us to quickly redirect deliveries, use alternative modes of transport or new routes in the event of force majeure, such as blockades or port closures.

End of tab. 1

5	Compliance with quality and safety standards	Strict adherence to international standards to ensure product quality and safety during transportation.	This is especially important for products with a short shelf life. This ensures that the products reach consumers without loss of quality.
6	Flexibility in responding to changes in supply and demand	Rapid redirection of supplies to balance supply and demand.	It allows you to respond quickly to fluctuations in supply and demand in the market. When demand for agricultural products increases in certain countries, logistics ensures that supplies are quickly redirected to these regions, which helps maintain a balance between supply and demand.
7	Integration with global supply chains	Integration of the agricultural sector into global supply chains for smooth operation from production to market.	In today's economy, the agricultural sector is part of global supply chains that bring together producers, suppliers, processors, and retailers to optimize the operation of logistics systems in general.

Thus, international logistics is a key component of supply chain stability in the agricultural sector, as it helps to ensure timeliness, optimize costs, minimize risks, and ensure compliance with international quality standards. As a result, efficient international logistics contributes to global food security by enabling stable supplies of agricultural products to be maintained even in difficult conditions or in the face of rapid market changes [5].

The logistics of agricultural products in a wartime economy face numerous challenges that significantly complicate the efficient movement and supply of goods (Fig. 1).

Unfortunately, martial law imposes additional difficulties on the existing problems in the agricultural sector, which can affect both internal processes and foreign trade.

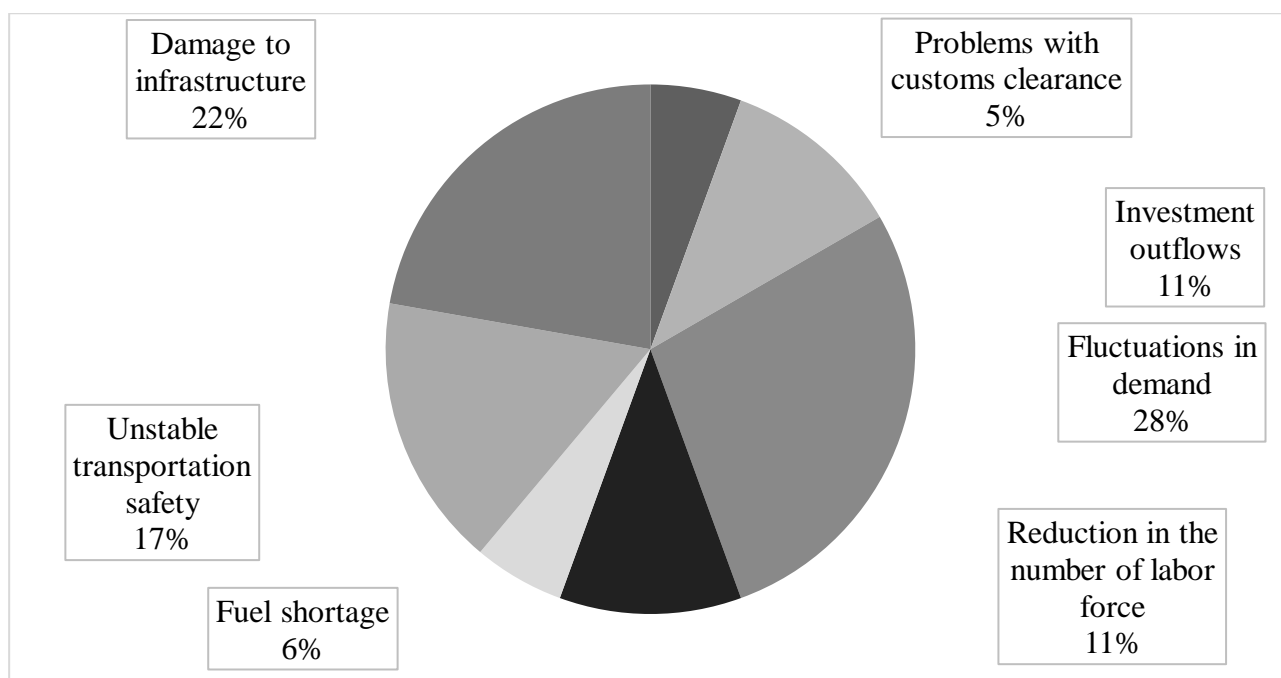


Figure 1 – Graph of the ratio of the main risks of logistics in a war economy, [10]

The main challenges facing the logistics of agricultural products are:

1. **Damage to infrastructure (roads, bridges, railways):** Military conflicts often lead to damage or destruction of critical transport infrastructure, which significantly complicates the delivery of goods to markets. This can cause delays in the transportation of agricultural products, increase costs, and reduce the availability of products on the market [7]. Destruction or damage to port and storage facilities can also lead to problems with the export and import of agricultural products, which limits the possibility of selling on foreign markets.

2. **Instability and insecurity of transportation:** During periods of hostilities, there are significant risks for transport, in particular due to the threat of shelling, mining of territories, sabotage of infrastructure, as well as the blocking of cargo movement routes. This can lead to frequent delays, loss of products, or even the complete inability to deliver. Transportation of goods becomes significantly more expensive and complex due to additional costs for security, cargo insurance, and the need to use alternative routes.

3. **Shortage of fuel and other resources:** Due to limited access to fuel or changes in its prices (for example, due to hostilities, sanctions, or blockades of supplies), the cost of transportation increases and the volume of transported cargo



decreases. This, in turn, leads to an increase in the cost of agricultural products on the market. Logistics companies may also face shortages of spare parts for transport, packaging materials, and other goods necessary for storing and transporting products.

4. Decrease in the number of the workforce: Partial or complete mobilization of the population leads to a decrease in the workforce in the industries that ensure the logistics of agricultural products. This can cause problems with delivery, processing of goods in warehouses, loading and unloading of goods, as well as with the management of supply chains. Migration of people from dangerous territories to safer ones can also reduce the availability of labor in key links of logistics processes.

5. Market instability and demand fluctuations: During times of hostilities, there may be a decrease in demand for certain types of agricultural products due to economic uncertainty, changes in consumer habits, and a decrease in the purchasing power of the population. This can create difficulties for logistics companies, as they cannot accurately predict the volume of transportation. The cost of agricultural products can become very unstable, which complicates the planning of logistics operations. In addition, rising transportation costs can lead to significant losses for businesses.

6. Problems with financing and investments: Due to the high level of risk in wartime conditions, the volume of investments in logistics infrastructure, in particular in the modernization of transport, warehouses, information systems, and other critical components, is significantly reduced.

7. Problems with customs procedures and international trade: In the event of war or economic sanctions, blockades or restrictions on the movement of goods across borders may be introduced. This complicates the export and import of agricultural products, especially if the country depends on foreign markets. Also, new customs restrictions or tariff increases may be introduced, affecting the cost of agricultural products and their delivery to foreign markets.

To find solutions to reduce risks, adaptive strategies for overcoming logistical challenges are proposed. They will become an important tool for enterprises trying to ensure uninterrupted operation in conditions of instability. They will allow rapid



response to changes in market conditions, infrastructure problems, or unforeseen events, such as war, economic crises, or natural disasters.

The first of these is the diversification of suppliers and routes. It involves avoiding dependence on one supplier or one transport route. This means creating backup suppliers or alternative supply routes to reduce the risk of delays or stoppages in supplies. For example, if one transportation route becomes dangerous or blocked, the company should have alternative routes, for example, through other ports or land transport. This allows reducing the risks associated with unforeseen events and ensuring the stability of supply [2].

The next strategy is flexibility in inventory management, which means ensuring the optimal level of inventory through demand forecasting and adaptation to conditions of instability. Using the Just in Case (JIC) principle instead of Just in Time (JIT) in conditions of high risks can be an effective way to manage inventory. Thus, in periods of uncertainty, enterprises can store larger stocks of goods or raw materials in warehouses to avoid supply disruptions. The advantage is the ability to reduce vulnerability to supply disruptions and ensure more stable operation of the enterprise.

No less important strategy is the use of digital technologies and analytics. The introduction of technologies for monitoring and forecasting logistics flows in real-time includes the use of the Internet of Things (IoT) to track cargo, Big Data to analyze demand trends, and artificial intelligence (AI) to optimize routes and predict risks. The establishment of a system for tracking transportation allows automatic response to delays, and the use of software for supply chain management helps to quickly change routes or suppliers. This helps to quickly adapt to changes in real-time, reducing risks and costs for logistics operations.

Another strategy is the localization of production and warehousing. Enterprises can reduce dependence on international or interregional supplies by developing local production and warehouses. This allows reducing transportation costs and increasing flexibility in the event of local or regional disruptions. This strategy helps to reduce transportation costs and maintain greater flexibility in

responding to local changes or problems [6].

Also, in the conditions of a war economy, an important element is mobility and alternative methods of transportation. The development of mobile and alternative transport solutions, such as the use of drones, electric trucks, or small-sized transportation, can be the key to overcoming the limitations of traditional logistics channels. For example, the use of autonomous trucks for transportation in areas where traditional methods of transportation are unavailable or unsafe. Alternative methods of transportation make it possible to minimize dependence on traditional infrastructure, which can be destroyed or damaged.

It is proposed that logistics companies create strategic partnerships with other companies or specialized logistics operators to overcome logistical challenges and ensure greater stability and reliability of supplies. This could be cooperation with other companies to share warehouse space or vehicles in the event of supply restrictions. Such actions reduce costs and risks through the joint use of resources and reduce the impact of potential disruptions [8].

The next strategy is flexible workforce management. Enterprises can reduce or expand the number of employees depending on the situation. The use of freelance or temporary labor during periods of peak demand or unstable conditions is popular, namely, the involvement of temporary workers to work in warehouses or in transport during peak periods, in particular during the harvest. This allows quickly adapting the number of employees to changes in demand or volume of transportation, reducing the cost of a permanent workforce in conditions of uncertainty.

A necessary strategy, in our opinion, is flexibility in the pricing policy of the logistics enterprise. Logistics companies faced the problem of rising prices at the beginning of the full-scale invasion in February-March 2022, when there was a critical shortage of fuel in Ukraine, which provoked a sharp increase in its price. It is important to timely adapt the pricing strategy to changes in the cost of resources (fuel, raw materials, labor), in particular through dynamic price adjustments or the introduction of additional fees to cover changes in costs. This allows maintaining profitability and minimizing losses from unforeseen changes in the market [9].

The last, but no less important strategy, is risk forecasting and preparation for unforeseen situations: the introduction of systems for assessing potential risks and developing action plans for the worst-case scenarios, such as disruption of supply chains, natural disasters, or political crises, will ensure readiness for any unforeseen situations and allow maintaining control over supply chains even in crisis conditions. For example, it is worth developing scenarios in advance in case of blocking of the main supply routes or the transfer of military conflicts to the territory of the storage of goods, which will speed up the decision-making process in extreme conditions.

Adaptive strategies for overcoming logistical challenges allow enterprises not only to effectively respond to changes and crisis situations but also to use them as opportunities for development. Thanks to flexibility, innovative technologies, and strategic planning, companies can maintain stability and competitiveness even in conditions of high uncertainty [12].

Conclusion. Ensuring effective logistics of agricultural products in the conditions of a war economy requires significant efforts to adapt to new realities. The main factors that determine success in such conditions are flexibility, rapid response to changes in the situation, and the ability to optimize logistics chains, taking into account high risks. Enterprises should actively seek alternative transportation routes, diversify supply sources, invest in innovative technologies, and use available opportunities to adapt to new economic and security realities [3].

Adapting international logistics strategies in the conditions of a war economy requires flexibility, innovation, and close cooperation between states, companies, and international organizations. The introduction of digital solutions and the development of partnership initiatives are important tools for minimizing logistics risks, ensuring food security, and the stability of supplies in difficult conditions. This makes it possible to reduce dependence on traditional logistics channels and increase the resilience of agricultural sectors to crisis situations.

Thus, international logistics is an important element of the stability of supplies in the agricultural sector, as it can ensure timeliness, optimize costs, minimize risks, and ensure compliance with international quality standards. As a result, effective

international logistics contributes to global food security, providing the opportunity to maintain stable supplies of agricultural products, even in difficult situations and with sharp changes in the market.

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