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Mitigating the effects of Russia's invasion of Ukraine on global food security – does the transit of Ukrainian cereals through Poland matter?

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Abstract: The article presents the results of empirical research, which constitutes a case study focused on the route through Poland as an alternative export channel for Ukrainian grain, developed under the conditions of the Russia-Ukraine war. It employs analytical methods and statistical description. By analyzing the volume, dynamics, structure, and geography of the transit, the significance of this route in unleashing Ukraine's export capabilities and its role as a substitute for traditional routes during periods of disruption is assessed. It was established that almost exclusively corn and wheat are transited (in a quantitative ratio of 2:1). The railway crossings in Dorohusk, Medyka, and Hrubieszów are of key importance, as rail transport dominates in land transport, handling over 4/5 of the total mass of transited goods. More than half of the transited grain is transported by rail and road in scattered European directions, and only less than half reaches Polish Baltic ports, mainly Gdańsk (over 3/5) and Szczecin (almost 1/5). The degree of containerization exceeds 1/4. Practically all container cargo reaches the terminal in Gdańsk, while the port in Szczecin is the leader in bulk transport. The volume of Ukrainian grain transited through Poland is relatively small compared to Ukraine's export potential, and intercontinental transport concerns only a tenth of the grain transited through Poland. It was concluded that the route through Poland primarily serves as a new export channel for Ukrainian grain to the European market and only marginally substitutes traditional routes.

1 Introduction

The war in Ukraine has significantly impacted global agricultural markets, particularly the grain market [1]. Ukraine exports large volumes of this commodity (a key component in food and feed production), mainly to North Africa and the Near and Far East countries. According to 2021 data, just before the Russian invasion, Ukraine was among the leading producers of corn (42.11 million tonnes), barley (9.44 million tonnes), and wheat (32.18 million tonnes), ranking 5th globally for corn and barley production and 6th for wheat [2].

The war has reduced Ukraine's agricultural production capacity and limited its ability to agricultural products export [3,4]. The blockade of Ukrainian Black Sea ports disrupted the continuity of supply chains and led to a sharp rise in global food prices [5–7]. In response, alternative export routes for Ukrainian agricultural products were developed with the support of the European Union (EU), aiming to mitigate the negative impact of the Black Sea port blockades on global food security. The EU's "solidarity corridors" have partially offset the disruption of traditional export routes for Ukrainian grain; however, various logistical and infrastructural constraints limit their efficiency. EU initiatives aimed at expanding the Trans-European Transport Network have helped increase the capacity of transit routes [8], facilitating the reconfiguration of existing logistics links within global supply chains in pursuance of changing geopolitical conditions.

Due to its proximity to Ukraine and relatively well-developed transport infrastructure, Poland has become an important transit country (second only to Romania) for Ukrainian agricultural products [9]. Nevertheless, there remains a need for further modernization and expansion of transport and supporting infrastructure, especially in light of increasing goods flows in relations with Ukraine [10]. The smoothness of transit is particularly hindered by the insufficient capacity of border crossings between Ukraine and Poland [9,11]. Additional barriers to the development of the transit route through Poland include the limited transport capacity of Polish railways and the insufficient handling capacity of Polish seaports [12]. Despite these limitations, Poland's role as an intermediary enables the redirection of relatively large volumes of goods from Ukraine to Western and Northern European countries, as well as to non-European markets. However, the route through Poland, compared to the route via Ukrainian Black Sea ports, involves a significantly longer land segment and, given the geographic location of Ukraine's traditional grain importers, often a much longer maritime segment.

The aim of this study is to determine the role and significance of the transit route for Ukrainian agricultural products passing through Poland, based on an analysis of the volume, dynamics, structure, and geography of the transit.

2 Materials and methods

This study utilized source data provided by the Polish Ministry of Finance, extracted from the New Computerized Transit System (NCTS), which records transit operations conducted within the EU territory. The data cover the transit of five main types of grain (corn, wheat, barley, rye, and oats) from Ukraine through Poland during the period from 1 January 2022 to 31 August 2024 (2 years and 8 months, with just over 2.5 years falling within the period of the war in Ukraine).

The research is empirical and constitutes a case study concerned with the route through Poland as an alternative export channel for Ukrainian grain, focused on key findings from the point of view of logistics, in particular management of material flow and optimization of transport processes. It employs analytical techniques and statistical description methods:

- structural analysis – concerned with the commodity structure of transit (the share of individual types of cereals in the mass of transported grain) and the structure of transit by type of transport (rail and road);
- spatial analysis – allows to determine the importance of individual border crossings and seaports in handling transit, and the importance of individual importing countries as target markets;
- temporal analysis – allows to recognize the variability of the flow of goods in a monthly breakdown, which was the basis for assessing the stability of transit flow;
- statistical analysis – was the starting point for assessing the size, dynamics, structure, and geographical distribution of Ukrainian grain transit through Poland.

Diagrams and infographics were used to visualize the information obtained as a result of processing the source material.

3 Results

Between 1 January 2022 and 31 August 2024, Poland served as a transit country for nearly 4 million tonnes of Ukrainian grain. The average annual volume of transit was therefore 1.5 million tonnes. Considering Ukraine's export potential, this is a relatively small amount, given that in 2022 alone, despite the ongoing war, Ukraine exported over 38.6 million tonnes of grain [2].

The volume of Ukrainian grain transited through Poland was significantly smaller than the volume of grain exported from Ukraine to Poland. Data from NCTS indicate that the transited volume amounted to 0.71 million tonnes in 2022 and 2.04 million tonnes in 2023. In contrast, according to the latest data provided by the Food and Agriculture Organization of the United Nations [2], the volume of exports to Poland in 2022 reached 2.74 million tonnes. In 2023, temporary deviations from the trade liberalization measures introduced in June 2022 between the EU and Ukraine [13] were in place. Notably, the Polish government imposed controversial in terms of legality unilateral import bans on certain Ukrainian agricultural products, and at the EU level, regulations temporarily allowed only transit through member states located close to Ukraine, including Poland. In 2022, when duty-free, unrestricted trade with Ukraine was possible throughout almost the entire second half of the year, the volume of grain imported by Poland was nearly four times greater than the volume transited. These data indicate the scale of the load on the transport system, in particular the border crossings between Ukraine and Poland, with individual flows of goods (imported and transited).

The dominant grain transited through Poland was corn (65.8%), which, together with wheat (32.4%), made up almost the entire volume of transit. Barley, the third most significant grain, accounted for only 1.7% of the transited mass of grains. The share of other grains was negligible (below 0.1%). The structure of transited cereals by type is shown in Figure 1.

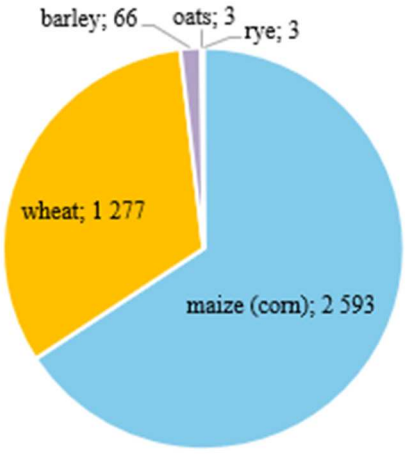

Figure 1 Structure of Ukrainian grain transited through Poland from 1 January 2022 to 31 August 2024 (data in a thousand tonnes)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

The grain entered Poland through five border crossings: Dorohusk (rail and road crossing), Medyka (rail and road crossing), Hrubieszów (rail crossing), Hrebenne (road crossing), and Korczowa (road crossing). 82% of the grain mass was transported by rail, while the remaining 18% was transported by road.

Almost half of the total flow (49.3%) passed through the Dorohusk crossing (39.5% by rail and 9.8% by road).

The Medyka crossing accounted for 27% of the transit (26.3% by rail and 0.7% by road), and the Hrubieszów rail crossing contributed 16.1%. The road crossings at Hrebenne and Korczowa handled 4.2% and 3.4% of the grain mass, respectively. The importance of each border crossing in the transit of Ukrainian grain is illustrated in Figure 2.

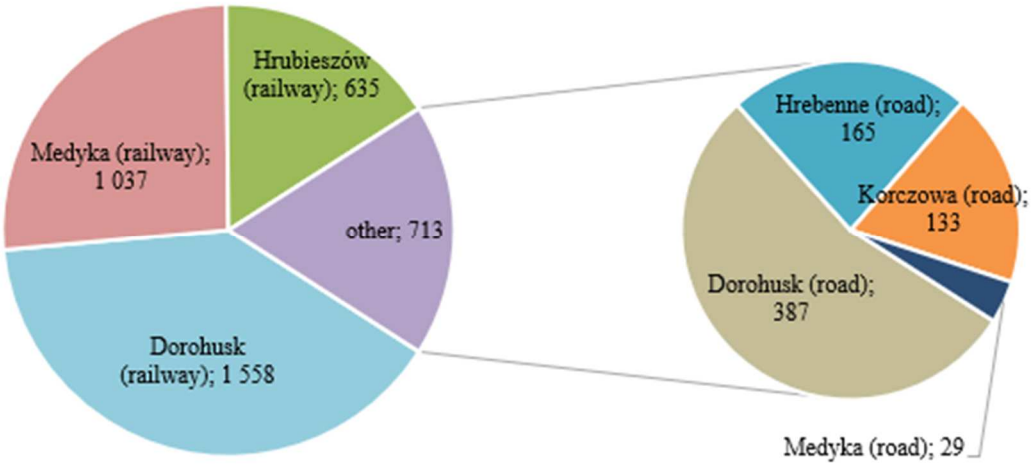

Figure 2 Significance of border crossings in the transit of Ukrainian grain through Poland from 1 January 2022 to 31 August 2024 (data in a thousand tonnes)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

The share of each transport mode in the transit of Ukrainian grain through Polish territory was identical to the share observed at the border crossings, with rail transport handling 82% of the total grain mass and road transport handling 18%. Although detailed records tracking individual shipments were not available, the consistent proportions in the types of transport used at both the border entry points and throughout the Polish transit route suggest that the same transport mode was maintained across the entire land journey.

A total of 51.8% of the transited grain, amounting to over 2.04 million tonnes, was distributed via land transport to various European destinations. The remaining 48.2% (just under 1.9 million tonnes) was shipped to Polish Baltic Sea ports, with Gdańsk receiving the largest share (30.7%), followed by Szczecin (9.5%), Gdynia (3.3%), Świnoujście (2.5%), and Kołobrzeg (2.1%). This distribution is visualized in Figure 3.

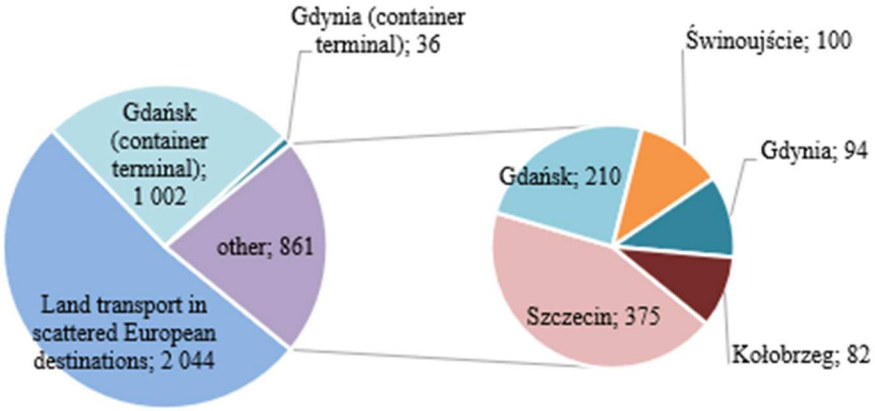

Figure 3 The role of maritime transport in the export of Ukrainian grain transited through Poland and its structure by ports and transport methods from 1 January 2022 to 31 August 2024 (data in a thousand tonnes)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

Considering that both the characteristics of the goods in transit (homogeneity, high natural, technical, and economic transportability) and the very poorly diversified type structure of the grain in transit (as shown in Figure 1) favor mass transport, the degree of containerization of transport can be considered high. As much as 1.06 million tonnes of grain were transported by land – both to the border crossings and through Polish territory – in

containers, accounting for 27% of the total transited grain mass.

Nearly all container shipments (1.04 million tonnes, or 97.6%) reached Polish seaports (as visualized in Figure 3), and then almost always the transport continued (by sea) in containers. The container terminal in Gdańsk dominated container transport, handling over 1 million tonnes of Ukrainian grain, which represents 94.2% of the grain transited in containers. The container terminal in Gdynia received 3.3% of the containerized grain mass, while the remaining 2.5% was distributed via land transport across various European destinations or loaded in various Polish seaports into the holds of bulk carriers.

Unlike land transport, maritime transport was predominantly container-based. The share of containerized transport in maritime operations was 54.7%, more than double the share in land transport (27%). Meanwhile, the key role in the mass transport of Ukrainian grain was played by the port in Szczecin, with transshipment exceeding 375 thousand tonnes.

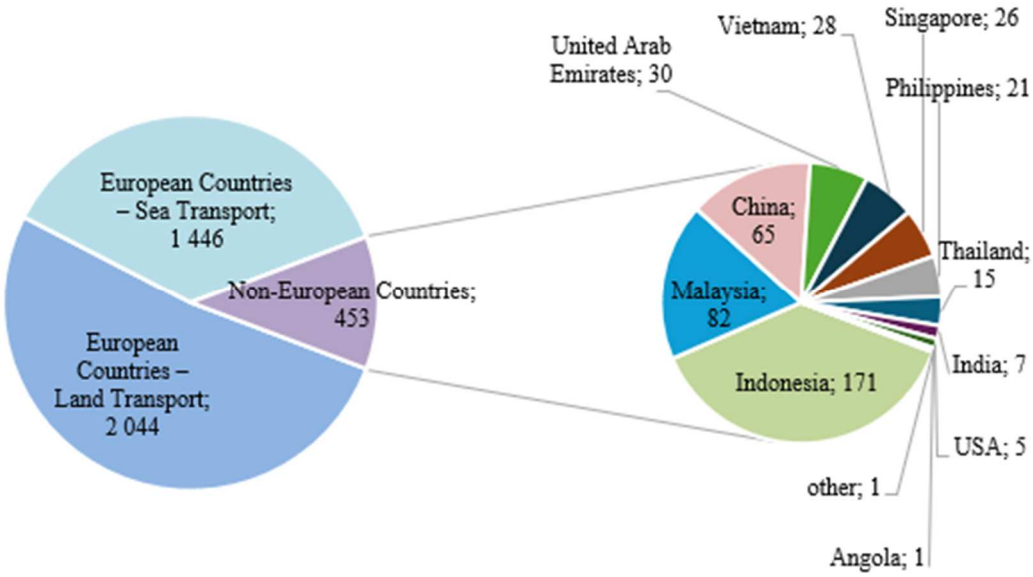

Figure 4 Geographic structure of exports of Ukrainian grains transited through Poland from 1 January 2022 to 31 August 2024, with emphasis on intercontinental exports (data in a thousand tonnes)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

Analysis of Figure 4 reveals that nearly 3.5 million tonnes out of the slightly more than 3.9 million tonnes of transited grain (i.e., 88.5%) were destined for European countries, predominantly EU member states. Apart from the EU member states, the United Kingdom was a significant European recipient (over 115,000 tonnes). Intercontinental maritime transport accounted for just under 453,000 tonnes of grain, representing 23.8% of the total grain volume that passed through Polish seaports, and only 11.5% of the total mass of Ukrainian grain transited through Poland. This means that the route leading through Poland primarily serves supplies to the EU internal market. Its role as an alternative route for the export of Ukrainian agricultural products to traditional sales markets is marginal.

Among the non-European destinations, only Indonesia received more than 100,000 tonnes (171,000 tonnes). While notable, this volume is small considering Indonesia's large population and the fact that the data spans a period of over 2.5 years. The high degree of containerization in maritime transport facilitated dispersed deliveries, resulting in a wide range of smaller, fragmented end recipients.

In summary, the transit of Ukrainian grain through Poland predominantly supplies the EU internal market, with minimal engagement in long-haul exports to traditional markets in Africa, the Middle East, and Asia.

From the point of view of ensuring the permeability of the transport system, it is important how transport is distributed over time. According to Figure 5, following the liberalization of trade relations between the EU and Ukraine in June 2022, the monthly transit volumes ranged from 50,000 to 261,000 tonnes. The peak volume recorded in a single month is equivalent to the cargo load of approximately 120 standard 600-meter-long freight trains. This means that even if the entire volume was transported exclusively by rail, handling the transit would only require 4 freight train sets per day. Given that the key border crossing for the transit of Ukrainian grain in Dorohusk has the capacity even for a dozen pairs of freight trains daily, it becomes evident that the transit of Ukrainian grains places a relatively low demand on the capacity of the Polish transport system.

In conclusion, while the transit volumes have shown significant variability, the absorption of these flows by

Poland's rail and road networks does not appear to strain the existing infrastructure excessively. Instead, the bottlenecks are primarily at the border crossings rather than throughout the broader transport system within Poland.

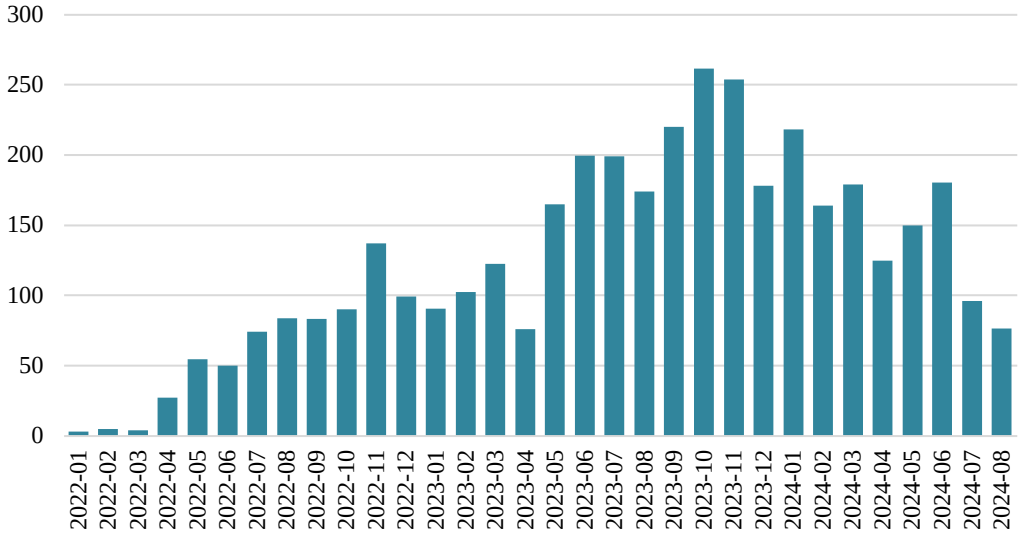

Figure 5 Monthly distribution of transit shipments of Ukrainian grains through Poland from 1 January 2022 to 31 August 2024 (data in a thousand tonnes)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

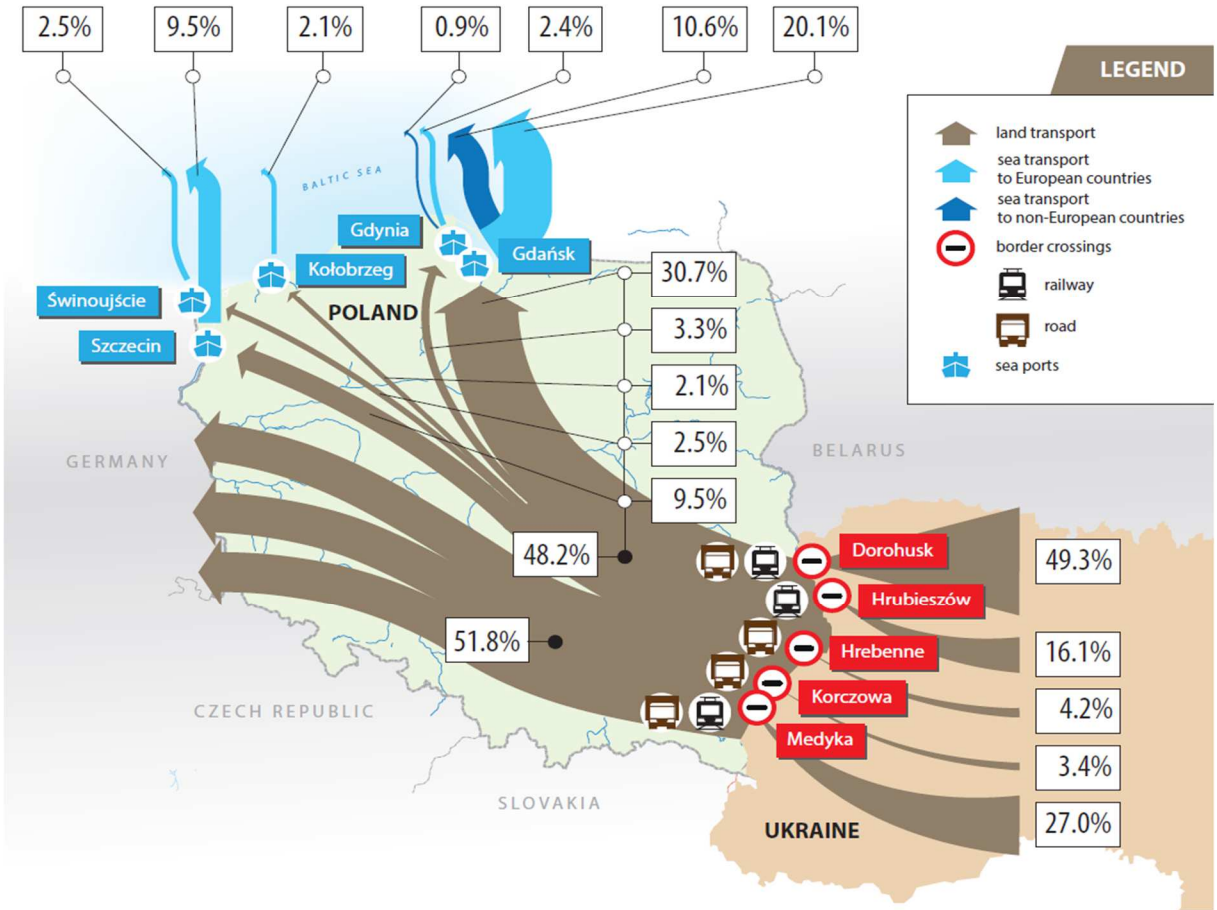

Figure 6 Schematic diagram of Ukrainian grain transit through Poland (1 January 2022 – 31 August 2024)
Source: Own study based on NCTS data provided by the Polish Ministry of Finance.

Figure 6 visually represents the key transit routes for Ukrainian grain passing through Poland during the analysis period. The diagram consolidates significant details from earlier considerations into a single graphic overview. The thickness of the arrows is proportional to the mass of the transported grain, and the accompanying percentage values indicate what proportion of the total mass of transited grain was transported via a given route.

4 Discussion

The directions and intensity of trade flows between countries are significantly influenced by geopolitical factors, as exemplified by the global reconfiguration of logistical links between countries following Russia's invasion of Ukraine [14], including the shifts in the streams of grain exports from Ukraine [15]. The issue of exporting Ukrainian agricultural products (mainly grains and oilseeds) during the Russian-Ukrainian war is frequently addressed in economic research, which focuses particularly on formulating recommendations useful for economic policy and business practices – specifically, indicating actions that should be taken to increase the efficiency of transit. This line of research concentrates on identifying bottlenecks in the transport system and optimizing logistical processes [11,16-18]. Another research focus is the implications of exporting Ukrainian goods via alternative, roundabout routes, including the quantification of the increase in negative environmental externalities associated with transport (due to the inability to use traditional export routes). The use of alternative roundabout routes requires higher energy consumption, which not only leads to increased transportation costs due to higher fuel consumption but also results in greater emissions of pollutants [19].

Studies examining changes in the volume of Ukrainian exports and their geographical structure focus on measuring the trade creation and trade diversion effects [20]. In EU member states located near Ukraine, much attention is paid to establishing the economic consequences of increased imports of agricultural products from Ukraine (in periods when free trade between the EU and Ukraine was possible) and transit leakage (in periods when imports of some agricultural products were not allowed). Due to the non-competitiveness of exports via roundabout routes through EU countries to traditional markets compared to exports to the EU, there was an influx of Ukrainian agricultural products into the EU internal market, which led to a drastic drop in prices [10]. The resulting agricultural market crisis triggered farmer protests. The serious problems associated with this prompted researchers to measure the scale of the influx of Ukrainian agricultural products and assess the impact of increased imports on domestic agricultural markets [21]. This represents a local dimension of agricultural market turbulence, paradoxically caused by excessive supply [22] (resulting from the liberalization of trade relations between the EU and Ukraine), while from a global perspective, the core of the grain crisis lies in the difficulty of supplying traditional recipients of Ukrainian agricultural products during the war in Ukraine [23], i.e., insufficient supply. The issue of declining global food security due to the war in Ukraine, including the problem of the expanding geographical scope of hunger and malnutrition, draws attention from researchers [24-27]. Another important aspect of research is food safety during wartime when the quality of agricultural products declines [28,29].

5 Conclusions

The volume of Ukrainian grain transiting through Poland (approx. 1.5 million tonnes per year) is relatively small compared to Ukraine's export potential, which, even under wartime conditions, amounts to around 40 million tonnes annually. Almost exclusively, corn and wheat are transited (in a 2:1 ratio). Ukrainian grain declared for transit enters Poland via five border crossings, of which the railway crossings in Dorohusk, Medyka, and Hrubieszów are of key importance. The transit of Ukrainian grain across Polish territory is dominated by rail transport, which handles over four-fifths of the total mass of transited goods. The same proportions apply to deliveries to border crossings, indicating that there is no change in the type of transport used for transit across Poland. More than half of the transited grain is transported by rail and road to various dispersed European destinations. The remaining portion goes to five Polish Baltic ports, mainly to Gdańsk (just under 65%) and Szczecin (almost 20%). Poland's largest grain port, located in Gdynia, plays a minor role in the transit. Although grain is a bulk commodity, intermodal transport, combining different transport modes (road, rail, sea) using containers as the cargo unit, plays a significant role in its transit through Poland. More than a quarter of Ukrainian grain is transited in containers. Almost all containerized cargo goes to the terminal in Gdańsk. Long-distance maritime transport concerns a tenth of the grain transited through Poland and is dominated by the port in Gdańsk (with a small share handled by the port in Gdynia).

This means that the route through Poland primarily serves as a new export channel for Ukrainian grain to the European market and only marginally substitutes traditional routes, supplying previous recipients whose food security – unlike European countries – is highly sensitive to disruptions in the continuity at moderately priced supplies.

The development of the transit route through Poland as an alternative export route for Ukrainian grain depends on various factors, including the military situation in Ukraine, the availability of traditional routes, geopolitical conditions, the extent of the EU's involvement in developing solidarity corridors, the scope and intensity of cooperation between Ukraine and Poland, and progress in investment and organizational improvements (including in the area of harmonizing trade procedures between the EU and Ukraine). Given the need to ensure a high level of global food security, efforts should be made, in particular,

to ensure that the route through Poland primarily serves as an alternative supply channel for traditional recipients of Ukrainian agricultural produce, i.e., poorer countries of the Global South, rather than as a channel for expansion into the markets of wealthy European countries. Strongly increased export to the EU destabilizes local markets, which, in turn, prompts authorities to introduce additional financial aid measures for farmers. This results in a paradoxical situation where the openness of the EU market to agricultural products from Ukraine is accompanied by ad hoc support instruments for local producers, justified by the need to compensate farmers for the drop in agricultural product prices due to the increased influx of these products from Ukraine.

Author contributions

Conceptualization, A.S.; methodology, A.S.; formal analysis, A.S., P.W.-A. and J.Z.; investigation, A.S.; data curation, A.S.; writing, A.S. (sections 1–5), P.W.-A. (section 1) and J.Z. (section 4); visualization, A.S.; supervision, A.S.; funding acquisition, A.S., P.W.-A. and J.Z.

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