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RUSSIA-UKRAINE WAR: TRANSPORT AND LOGISTICS SUPPORT FOR GRAIN SUPPLY CHAIN IN REGIONAL FOOD SAFETY

Summary. With the agricultural industry being vital for regional food safety, the extreme conditions under which it operated in Ukraine during the first half of 2022 has offered a unique insight on vulnerabilities of supply chains as well as the necessity of ensuring transport and logistics support for grain supply chain using adaptive methods. During that time frame, existing infrastructure, logistics, and involved materials were at risk of being stolen or by being destroyed due to direct combat damage or resulting fires. Established food transportation routes suffered from blockades, destruction, or congestion. Switching modes of transport for crop grains proved difficult with the absence of required transport and logistics support. The switch to vegetable oil transport proved harder still. Meanwhile, the re-established naval transportation shed a spotlight on GIS instruments that became critical for the safety of regional food supply chain. This inspired the idea of implementing methods of assessing the safety of transport facilities with the direct participation of the user based on geographic information. These methods can be key in enabling new export routes as part of a stable grain supply chain, supporting logistics behind constructing pipelines for transportation of vegetable oils. As the

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food safety of the world depends on new export routes, ensuring their efficiency and security will always remain relevant.

Keywords: transport logistic, food transportation, regional safety, efficiency assessment, risk management, grain losses, combat damage, martial intrusion

1. INTRODUCTION

Crimea's annexation in 2014 started a crisis, which consequence was Russian attack on Ukraine in 2022 [1]. War brings, in addition to physical aggression, a number of other repercussions in various areas and of varying scope also globally; Ukraine's neighbors, developing countries and emerging markets were infected with it first [2,3]. Food is one of the most traded goods by Ukraine and the 2022 war affected it in a serious way, affected economies to explore and find alternative food supply chains partners on other continents [4,5]. It also lead into a phenomenon of purchasing more food by the citizens also from outside Ukraine as a spare was also visible [6,7]. Many experts think, war in Ukraine will affect a third food crisis within the next 15 years [8]. In the case of the global economy experts think it will lead to reducing global GDP by 1 percent by 2023 (which is \$1 trillion) and up to 3 percent to global inflation in 2022 and 2 percentage points in 2023 [5,9]. The crisis was also visible in the financial markets [10]. As for other industries, products that were transported through Ukraine and Russia in the first place were also infected, e.g. automakers [11], energy markets [12,13].

The proposed review covers the first half of 2022, which is a relatively limited period for analysis, especially given the martial law conditions that have prevailed in Ukraine for more than five months as a result of Russia's full-scale armed aggression against the Ukrainian State and not only. This imposes certain requirements for reporting emergencies of various levels. At the same time, the relevance and necessity of the publication is noted. For 6 months of 2022, compared to the same period of 2021, the number of fires increased by 40.3%, the number of people injured in fires - by 31.3%, the number of injured children and adolescents under 18 years - by 17.3%, material losses - 11.4 times; at the same time, the number of people killed as a result of fires remained at the same level as last year - 49,041 fires were registered [14]. Among them, other causes – 9,069 cases (7.5 times increase), including 6,929 fires that arose because of Russian military aggression against Ukraine. This is without taking into account the fires that occurred in the territories of the Donetsk and Luhansk regions temporarily occupied since 2014 and the territories of the Autonomous Republic of Crimea and the city of Sevastopol, as well as in the territories of certain regions of Ukraine that were affected by Russian military aggression in the period from February 24 to June 30, 2022. A number of fires at grain warehouses were registered throughout June in Dnipropetrovsk, Donetsk, Zaporizhia, Mykolaiv and Kharkiv regions. For example, on June 6, in the village of Novoyakovlivka of the Komyshevaska STG, as a result of munition fire on the territory of the FSG "Dobrotvir", a fire broke out in the warehouse for grain crops (Fig. 1).

The warehouse building with an area of 3,000 m² and 100 tons of grain inside was damaged by fire. Fortunately, no death or injuries occurred. Material losses from the fire amounted to more than 1 million dollars. Russia is deliberately shelling grain warehouses in Ukraine, destroying crops and stealing Ukrainian grain, EU High Representative Josep Borrell said. "The EU does not ban the export of Ukrainian grain, nor the export of Russian grain or fertilizers. Nevertheless, Russia blows up grain warehouses, destroys the harvest and steals it, and blocks Ukrainian ports with military actions. There are difficulties in ensuring cargo safety in the Black Sea. And if grain and oil crops cannot leave Ukrainian ports, then there will be famine in the

world," he said in an interview with the French publication *Journal du Dimanche*. It is exceedingly difficult to solve this problem, because by the end of the summer harvest in Ukraine, 20 million tons must be removed from storage [15].



Fig. 1. Fire broke out in the warehouse for grain crops, the village of Novoyakovlivka, Zaporizhia region, June 6 [14]

2. METHODS & RESULTS

The method of assessing the safety of transport facilities with the direct participation of the user based on geographic information tools for monitoring the security of the grain supply chain. The principles of achievement of professional preparedness based on risk assessment of food safety engineering are used. Ukraine is the fourth-largest exporter of grain in the world. Now, with about 30 million tons of grain stored on territory Ukraine controls, attempts are made at exporting it by road, river and railway transport [16]. Russia is deliberately blocking Ukrainian ports and sea lines in the Black Sea for Ukraine's grain export, as well as hindering export by rail with missile strikes on elevators and railway infrastructure. For example, on June 4, Russian invaders destroyed Ukraine's second-largest grain terminal in Mykolaiv with rockets. As a result, warehouses with grain meal caught fire. The process of extinguishing the fire (Fig. 2) lasted until June 6. Ukraine lost approximately 250,000-300,000 tons of grain due to the destruction of the Mykolaiv grain terminal.

From the message of the First Deputy Minister of Agrarian Policy and Food Taras Vysotskyi in the news during an information telethon [17]. Physically, according to the registers, several hundred thousand tons of grain were stored there at the beginning of the war. Mainly it is wheat as a food product, corn, to a lesser extent - soy and sunflower seeds. It should be noted that the construction of temporary silos for Ukrainian grain in Poland may take 3-4 months. Deputy Prime Minister, Minister of Agriculture of Poland Henryk Kowalczyk wrote, however, this requires the development of many concrete solutions: location, size, supporting infrastructure, sources of financing, ownership issues, etc. granaries should be where the broad tracks from Ukraine end [18]. Then it will be easier to transship grain and thereby increase the carrying capacity, as the maximum amount of grain that can be transshipped in Poland is about 1.5 million tons, while Ukraine's capacity is about 5 million tons every month. To ensure high-

quality storage of grain in today's conditions is storage for an indefinite period, companies open and receive grain from other holdings, helping to get grain out of dangerous areas [19]. The supply of Ukrainian grain for the previous two seasons is characterized by both the loss of positions in key markets and a significant increase in supplies to non-typical. In 2020/21, almost 8.4 million tons of corn were delivered from Ukraine to China, which accounted for more than 32% of the projected import and was almost twice as much as for the same period of the previous season (see Table 1). In the barley segment, a significant increase in imports by China was also noted [20]. In 2020/21, more than 2.8 million tons of barley were delivered from Ukraine to China, which is 2 million tons more than in the same period of the previous season. At the same time, deliveries to the key importer, Saudi Arabia, decreased significantly (by 934,000 tons), reaching only 334,000 tons against 1,269,000 tons in the same period of the previous season.



Fig. 2. Fire of grain warehouses in Mykolaiv port, Ukraine, 4-6 June 2022 (from open sources)

Tab. 1

The largest importers of Ukrainian grain [mln tons]

| Country | Corn | | Wheat | | Barley | |
|--------------|---------|---------|---------|---------|---------|---------|
| | 2019/20 | 2020/21 | 2019/20 | 2020/21 | 2019/20 | 2020/21 |
| China | 4.23 | 8.35 | 0.83 | 2.81 | 0.83 | 2.81 |
| Egypt | 3.36 | 2.10 | 2.83 | 2.10 | | |
| Netherland | 3.23 | 1.93 | | | | |
| Spain | 3.69 | 1.77 | | | 0.36 | 0.51 |
| Iran | 1.16 | 1.01 | | | | |
| Portugal | 0.81 | 0.73 | | | | |
| Libya | | | 0.60 | 0.61 | 0.70 | 0.64 |
| Turkey | 1.75 | 0.58 | 1.35 | 0.72 | | |
| Indonesia | | | 3.68 | 2.39 | | |
| Bangladesh | | | 2.19 | 1.13 | | |
| Total export | 23.5 | 29.5 | 16.8 | 19.8 | 4.2 | 4.2 |

On the wheat sales markets, the main factor was the increased import demand of Pakistan, which traditionally provides domestic needs or is itself an exporter. Ukraine delivered 1.4 million tons of wheat to Pakistan. It is also worth noting the changes in supply to the key markets of Egypt and Indonesia (Fig. 3). Indonesia is traditionally a key market for Ukrainian wheat and shares the leading position among importers with Egypt.

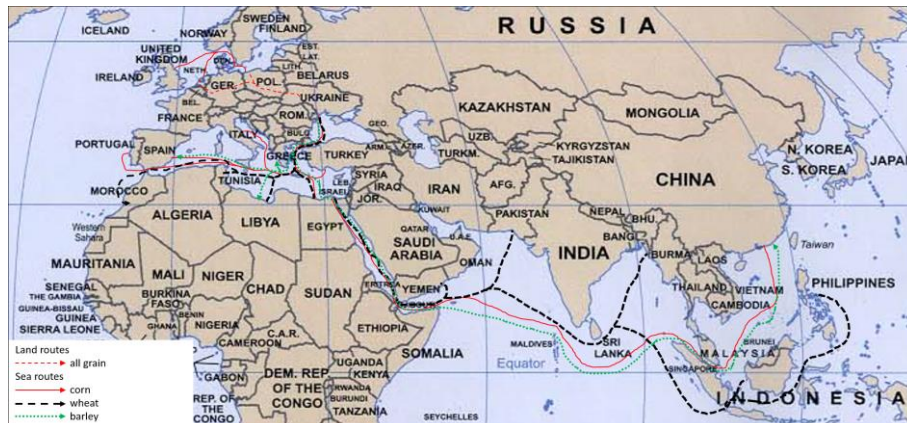


Fig. 3. Regional sea routes of grain supply from ports of Ukraine, 2020-2021

Several elevators on the left bank of the Dnipro ship wheat to mills for processing to ensure the food safety of the state in flour. In addition, elevators ship the grain of third-party undersigned contracts to Europe. Nevertheless, there are problems with this - there are no logistics. If it is possible to promptly load wagons with grain on route elevators, the approval of transportation plans and electronic applications at AS "MESPLAN" is problematic. In addition, the stations of Izov, Chop, Uzhhorod are extremely congested [21]. The task of the state is to ensure food safety (Fig. 4) regardless of how long the martial law lasts.



Fig. 4. Destroyed village in rural district of Kyiv region, Ukraine, April 2022 (from open sources)

The government has taken a step to preserve stocks by prohibiting the export of wheat. However, it is allowed to export such crops that are a feed necessity - corn, soybeans, and others. The food crops that cover the Armed Forces' needs are not exported because the state needs to maintain its defense capability, while others can be sold abroad, not by sea transport, but by rail. 11 oil extraction plants operate in Ukraine. They process 10,000 tons of sunflowers per day, on average 4,500-5,000 tons of oil are produced. Most of the oil extraction plants are not working because almost 98% of the oil was exported through ports that are blocked today. The oil industry in Ukraine today faced two problems. The first is logistical. If grain is exported in millions of tons, then in April it was possible to export only 151,000 tons of oil, and 44,000 tons of meal. But for the plant to work, these indicators must be the same. If 30 wagons of oil and 20 wagons of meal are shipped per day, this is not enough. The domestic market is supplied with five times as much oil as the oil in sunflowers and the oil stored in factories. About 7 million tons of sunflowers remain in Ukraine, from which 3.5 million tons of oil can be produced. Annual consumption in Ukraine is about 400,000 tons [21]. Today, five Ukrainian ports are in uncontrolled territory (Fig. 5), seven more are blocked, and only 3 ports are fully functional: Reni, Izmail, and Ust-Dunaisk.



Fig. 5. Grain warehouses in Mariupol port (with destroyed Ukrainian coast guard boat in front), in uncontrolled territory of Ukraine, April 2022 (from open sources)

These ports have little congestion, so Ukraine is looking for alternative routes. Alternative export routes for agricultural products are the European ports of Gdynia/Gdansk, as well as railway containers, the largest throughput of which is 755 containers per day (over 15 million tons of grain).

3. DISCUSSION

In June 2021, Russia introduced a "floating" duty on the export of three types of grain (corn, barley, wheat). Its size is seventy percent of the difference between the average value of price indicators and the base part. So, for example, since May 20, the duty on the export of corn and barley is seventy-six and a half dollars per ton, and the duty on the export of wheat is one hundred and ten and a half dollars per ton. To date, Belarus has introduced a complete ban on

the export of wheat, Kyrgyzstan and Armenia are preparing to introduce tariffs and quotas, and Kazakhstan is categorically against tariffs, considering them an obstacle for local agricultural producers on the way to fulfilling international obligations. In addition to the destruction of agricultural machinery and warehouses, the "world's second army" simply stole Ukrainian grain and seeds. At the beginning of April, news about the illegal export of Ukrainian grain from the Donetsk, Zaporizhzhia, and Kherson regions appeared in the information space of Ukraine. In Russia, this news was presented as a "successful sale" of agricultural products and their export to the Russian Federation and Crimea. Russia exported 1.26 million tons of wheat in May, compared to 675,000 tons in May last year, according to the monitoring of the Russian Grain Union [22]. If exports have increased, this can mean only one thing - Russia managed to find buyers for stolen Ukrainian grain. For example: 100,000 tons of grain were exported from the Luhansk region alone in May. The stolen goods would last the local population for 2-3 years. In general, the Russian military stole more than 400,000 tons of grain from the occupied regions. At the same time, they loaded everything: both crops and garbage, so as not to leave anything for the farmers. Operational data of the State Customs Service, as of August 5, since the beginning of 2022/23, Ukraine exported 1.867 million tons of grain and leguminous crops [23]. As noted, for the same period of the earlier season, the specified indicator was 3.629 million tons. In terms of crops, since the beginning of the current season, the following were exported:

- wheat – 444 thousand tons (in 2021/22 – 1.25 million tons),
- barley – 165 thousand tons (1.312 million tons),
- corn – 1.249 million tons (1.049 million tons).

The total export of Ukrainian flour on August 5 amounted to 4.7 thousand tons (the earlier season - 13.4 thousand tons), including wheat - 3.9 thousand tons (13.5 thousand tons). Since August 1, when the implementation of the "grain initiative" began, 1.72 million tons of agricultural products have been shipped from the ports of Odessa, Chornomorsk and Pivdenny. A total of 68 ships left the unlocked ports during August, the ports of destination of which are located in 18 countries of the world. It shows how critical it is to the Ukrainian economy and global food security [24]. Already in September, the rate of transshipment through unblocked seaports at the level of at least 3 million tons of products are reached. For all modes of transport, export of at least 8 million tons are planned [25].

GIS instruments show the increase in transport support facilities and logistic routes to guarantee grain supply chain. It became critical for the safety of the regional food supply chain [26]. The first ship to transport grain from Ukraine since the war broke out, headed towards the Bosphorus, sailing on the monitor screen (Fig. 6) at a speed of 11.4 km.

The Razoni's arrival to Istanbul has been delayed by bad weather. 5.5 million tons of agricultural products were shipped on 241 ships from August 1 to September 30 through the ports of "Great Odesa". As part of the implementation of the Initiative on the safe transportation of grain and food products, from 01.08 to 26.09 (Fig. 7), Odessa seaports sent 218 vessels that exported 4.85 million tons of agricultural products to countries in Asia, Europe and Africa [28].

To ensure the transportation of grain based on the calculation of the average load of one bulk carrier of 0.0225 million tons, 222 trips are required for each 5 million tons proposed for export by the end of the year. Railways transport grain crops: wheat, barley, oats, rye, corn, soybeans. One hopper wagon transports up to 65 tons of products. Above 71,500 such wagon trips are needed for the delivery of the same amount of grain. The latest vessel traffic is shown in Fig. 8.

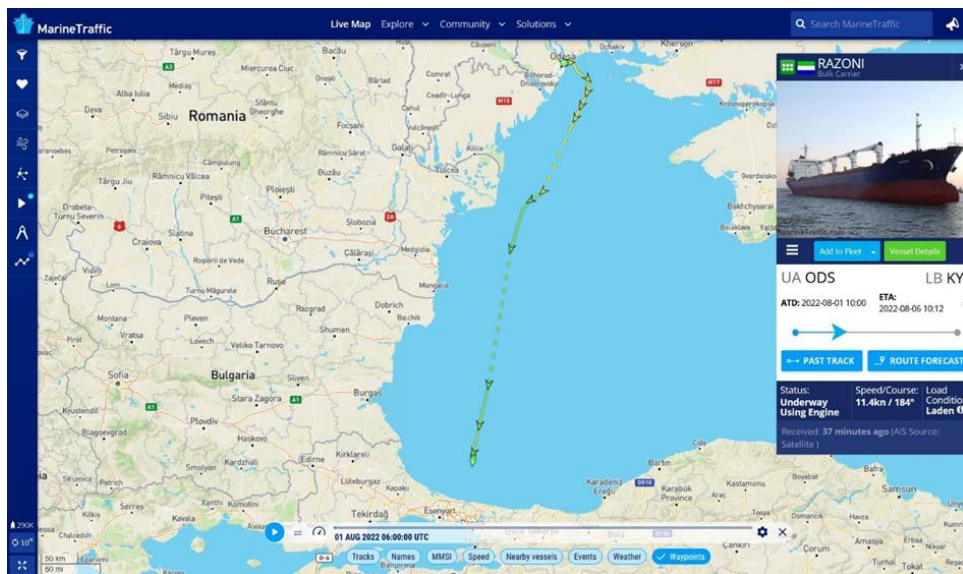


Fig. 6. Grain supply recovering [27]

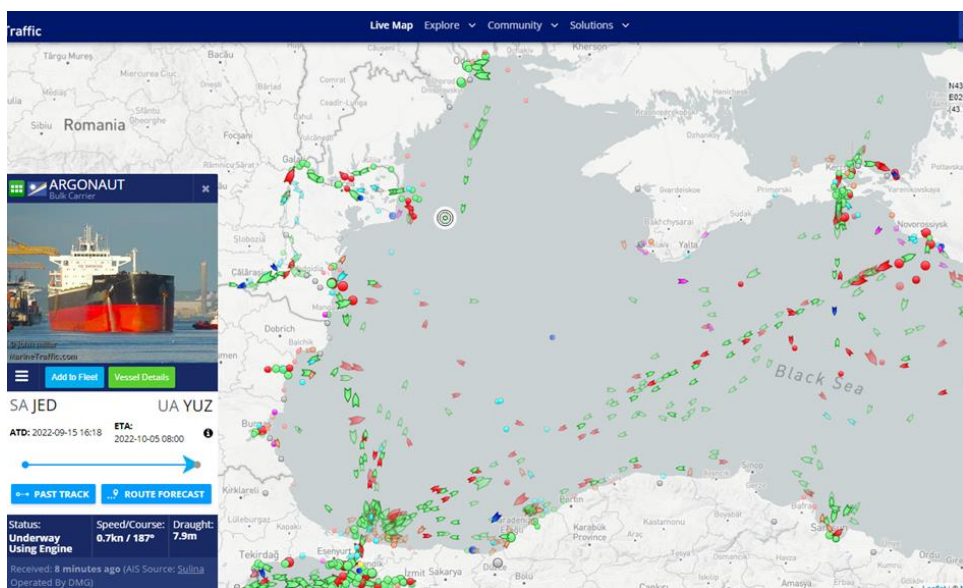


Fig. 7. Grain supply under GIS platforms monitoring [29]

4. CONCLUSIONS

Supply chain risk management is one of the issues that is considered in the field of supply chain management, and its importance is increasing every day. The transport industry is one of the critical industries in every country, and the risks of that must be given special attention. The main purpose of this research is to identify, assess, and respond to the procurement risks of the grain of automotive shipping. The export routes of Ukrainian agricultural products through the countries of the European Union should become permanent and are the main statement during the plenary meeting of the ministers of agriculture of the EU member states, Moldova, Georgia and Ukraine on ensuring food security. The proposed method of assessing the safety of transport

facilities with the direct participation of the user based on geographic information tools ensures the effective functioning of the information system for monitoring the safety of the grain supply chain. The principles of achievement of professional competence in preparation of educational programs on risk assessment of engineering of fire safety are offered. First, it is necessary to build terminal complexes on the border with EU countries, which will include grain conveyors, and with the help of which Ukrainian grain will be transported without interruption. The construction of such infrastructure is due to the difference between Ukrainian and European tracks. Each of those terminals will be able to transport up to 2 million tons of grain per year. The next, construction of a pipeline for the transportation of vegetable oils. The pipeline will connect the loading terminal on the territory of Ukraine and the unloading terminal in the European seaport. According to calculations, the capacity of such transportation should be 2 million tons per year. The third problem is the insufficient number of railway hoppers in EU countries that can transport grain, as well as the corresponding trucks. 22,400 hoppers operate in Ukraine and approximately 12,000 in all EU countries. Therefore, an increase in the number of such wagons by 3,640 units and trucks by 6,000 units will allow additional transportation of up to 10 million tons of grain per year. Fourthly, it is necessary to allocate railway routes for the passage of Ukrainian grain wagons with carts modified to the standard of European tracks through the territories of Poland and Germany to the Polish port of Gdansk and the German ports of Rostock and Hamburg. The food security of the whole world depends on new export routes. In particular, subsidies for 50% for the production of trucks and railway hoppers intended for the transportation of grain from the EU, and for the construction of a complex of terminals and a pipeline for vegetable oils and grain transshipment terminals.

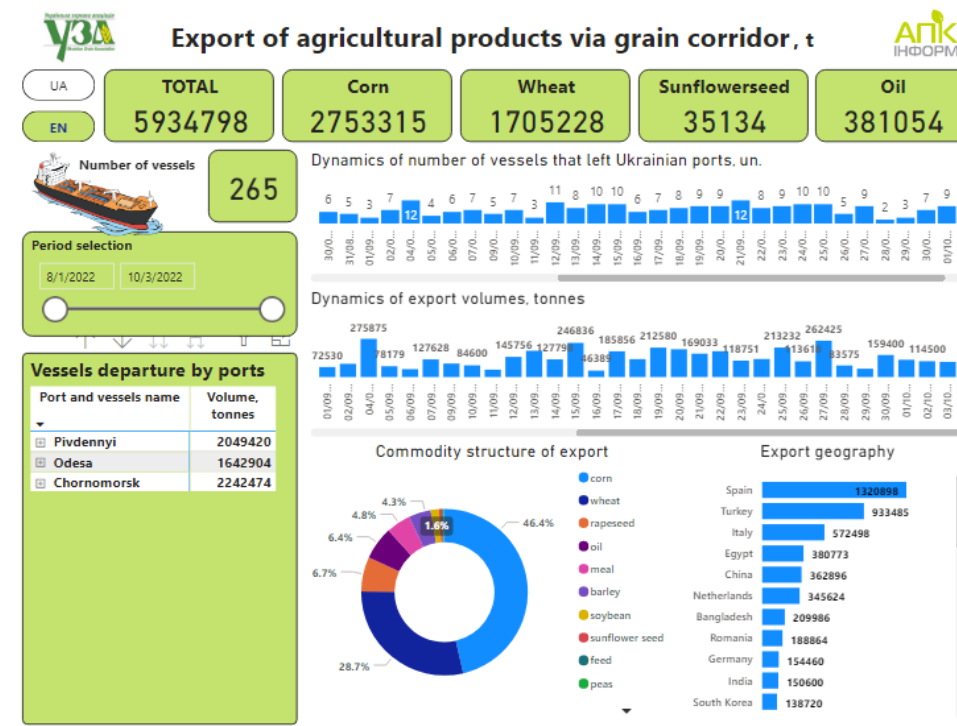


Fig. 8. Results of two months of Grain corridor food supply chain [30]

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