

The War in Ukraine and Its Impact on Global Agricultural Trade

Auswirkungen des Ukrainekriegs auf den globalen Agrarhandel

Mariia Mykhailova¹, Olha Yatsenko², Yuliia Zavadska³, Oksana Afanasieva⁴, Rainer Haas^{5*}

¹ Department of Marketing, Reputation and Customer Experience Management, State Biotechnological University, 61002 Kharkiv, Ukraine

² Department of International Trade and Marketing, Kyiv National Economic University Named After Vadym Hetmana, 03680 Kyiv, Ukraine

³ Product Development Team, Loopme, 04123 Kyiv, Ukraine

⁴ Department of Marketing, Reputation and Customer Experience Management, State Biotechnological University, 61002 Kharkiv, Ukraine

⁵ Institute of Marketing & Innovation at the University of Natural Resources and Life Sciences, Vienna, 1180 Vienna, Austria

* Corresponding author: rainer.haas@boku.ac.at

Received: 1 May 2023, received in revised form: 27 October 2023, accepted: 30 November 2023

Summary

The Russian invasion of Ukraine represents an unforeseen and significant market disruption for global trade with wide-ranging effects on global trade, particularly on the economies of the major import countries of Ukrainian agricultural commodities. The general impact and consequences of the war on the global economy are described, and key components of the market disruptions are identified and put into a historical and geographical context. The degree of interconnectedness between the war in Ukraine and world trade and global gross domestic product (GDP) indices is highlighted. Changes in production and export volumes of the main Ukrainian agricultural commodities and their impact on major import countries are described. Actual and future measures to stabilise and soften the volatility of affected agricultural markets are presented.

Keywords: agrifood market, the war in Ukraine, international agricultural trade, global trade of agricultural products, food security, supply chain disruptions

Zusammenfassung

Die russische Invasion der Ukraine stellt eine unvorhergesehene und signifikante Marktstörung mit weit reichenden Effekten auf den globalen Handel als Ganzes, und speziell auf die Volkswirtschaften der größten Importländer von ukrainischen landwirtschaftlichen Rohstoffen dar. Die Auswirkungen und Konsequenzen des Kriegs auf die Weltwirtschaft werden beschrieben und Schlüsselkomponenten der Marktstörungen werden identifiziert und in einen historischen und geographischen Kontext gesetzt. Das Ausmaß der Verflechtungen zwischen Ukrainekrieg und Welthandel und den globalen GDP Indizes zeigt die Signifikanz der Marktstörungen. Die Veränderungen in der Produktion und des Exportvolumens der wichtigsten ukrainischen Agrargüter und deren Auswirkungen auf die Hauptimportländer werden dargestellt. Aktuelle und zukünftige Maßnahmen zur Stabilisierung und Abfederung der Volatilität der betroffenen Agrarmärkte werden diskutiert.

Schlagwörter: Agrar-Lebensmittelmärkte, Ukrainekrieg, internationaler Agrarhandel, globaler Handel agrarischer Produkte, Lebensmittelsicherheit, Lieferkettenstörungen

1. Introduction

The Russian military invasion of Ukraine has caused serious problems for the world trade of agricultural products and has jeopardised not only geopolitical stability but global food security as well. The consequences of the war in Ukraine have a global manifestation in all spheres, primarily in the economic sphere. Ukraine plays a significant role in international global agricultural markets, and its production accounts for a considerable share of the global agrarian production. Thus, before the war started, Ukrainian agricultural producers occupied the first place in sunflower seed production, the third place in honey export and the fourth place in corn export on the global food market (FAS, 2022a). On a global scale, Ukrainian agricultural production reached a share of 20% in sunflower production, 4% in sugar beet production, 3% in rape production, 2% in cereal production, including 8% in barley and 3% in wheat production, 2% in cow milk production and 1% in pork, beef and poultry production (UKRCENSUS, 2020).

As a result of the conflict, global chains of agricultural products, particularly sunflower seeds, honey and sweet corn, which Ukraine had been supplying to the global market, have been interrupted or broken. This has led to aggravation in food price instability and reduction of availability to consumers in numerous countries. Substitution of the Ukrainian supply of these products may be a challenge since Ukraine has been a major supplier to many countries. In particular, a number of Asian, African, Near East and European Union (EU) countries have been massive importers of Ukrainian sunflower seeds. Should they lose the sunflower seed supply from Ukraine, they will seek alternative supplies from other countries, such as Turkey or Romania. However, substituting the Ukrainian supply may be limited since Ukraine has been one of the largest world exporters of sunflower seeds. Sweet corn is also a significant crop in the feed sector of these countries. The increase in price instability and limited supply may have a negative impact on meat and milk production. Should the sweet corn supply from Ukraine decrease, the largest importing countries may turn to other large grain exporters, such as the USA, Brazil, Argentina or Canada, to satisfy the need for these crops. Moreover, Ukraine is a significant wheat producer. Wheat stores from Ukraine are also an essential reserve for global markets. Losing access to Ukrainian wheat may have grave consequences for the global bakery product and seed material markets.

Because of the key role Ukrainian production plays worldwide, for both developed and developing countries, it is vital to understand the impact of the war in Ukraine on the global

trade of agricultural products. It is estimated that after the coronavirus disease 2019 (COVID-19) pandemic, the share of highly food-insecure people doubled to 276 million. It was forecasted that this number would increase to 323 million in 2022 due to the war in Ukraine (Vickers et al., 2022). Therefore, the conflict in Ukraine has far-reaching consequences for global food security. Countries that depend on Ukrainian agricultural products are pushed to seek alternative supply sources, which may result in price instability and decrease in food accessibility for consumers around the world. The consequences of the Russian military aggression cause serious challenges for global food security. The decrease in agricultural product supply volumes from Ukraine is leading to increase in food prices, deterioration in food accessibility and the threat of an increased number of people facing starvation around the world. To ensure global food security, urgent measures must be taken. They must be directed to restore the agricultural sector of Ukraine and stabilise food supplies in the global market.

Simultaneously, the international agrifood market encounters several production and distribution challenges. Some can be attributed to the disruption of global supply chains due to COVID-19, some to production losses due to climate change and extreme weather events and some to the necessity to double agricultural productivity by 2050 (the expected increase in population will double the demand for food products by 2050) (Borsellino et al., 2020). These challenges increase the pressure to remove and prevent trade restrictions and distortions on global agricultural markets, to provide proper functioning of markets of food and its derivatives and to facilitate timely access to market information to limit food price volatility and, currently, to minimise the negative impact of the Russian full-scale invasion of Ukraine.

Under the conditions of global geopolitical instability caused by, among other things, the Russian invasion of Ukraine, which affected the ability of Ukraine to fully produce and export several agrarian products, to create critical reserves of national food security, countries and particular customs areas resorted to implementing numerous non-tariff measures to regulate agricultural product trade, including a full ban on such product exports (ITC, 2022). The situation is worsened by the fact that the war struck an economic system that had not fully recovered after the recession caused by the COVID-19 pandemic. The people of Ukraine suffer significantly not only from the war, but also from supply chain disruptions; however, people from all over the world feel the strain caused by a reduction of trade volumes and production due to the increase in prices of provisions and energy sources and the

decrease of goods exported from Ukraine, which has already triggered a considerable humanitarian crisis. Not only the provision of agricultural supplies, but also the whole system of agricultural production of countries is in jeopardy.

Therefore, the degree of interconnection between consequences of the war in Ukraine and the indices of global trade and global gross domestic product (GDP) may be estimated as middle to high. The impact of the war on these indices is already observable, but it also depends on other factors and global tendencies. The war has caused a considerable narrowing of trade channels. Disruptions in deliveries, ruined infrastructure and a decrease in consumer demand have resulted in reduction of foreign trade. This may affect the global volumes of goods and services trade. Moreover, the conflict in Ukraine has led to ruined infrastructure, decreased production and investment, a rise in unemployment and a drop in people's incomes. It has also resulted in a decline of global GDP. Since Ukraine is a significant player on the global market, such an influence may be quite notable. Ukraine is an important supplier and a transit country for energy resources, such as gas and oil. The war has led to disruptions in delivery of these resources to consuming countries, which has already influenced global markets of energy resources and their prices. The war in Ukraine has geopolitical consequences that effect the global politics and relationships among countries. It may further exacerbate geopolitical instability, which influences global trade and global GDP indices. However, it must be noted that a specific degree of interconnection depends on numerous factors such as the duration of the war, regional circumstances, economic policies and the reaction of the international community. These circumstances determine the urgency of defining the further degree of influence of the Russian aggression against Ukraine on global trade and global GDP indices.

The highly urgent topic of international agrarian product trade aspects within the Russian military aggression towards Ukraine is discussed in various works (e.g. Giordani et al., 2016; Malpass, 2022; World Bank, 2022a). However, global and regional challenges that appeared due to the war against Ukraine cause the necessity to mobilise scientific efforts to search for directions to overcome the existing crisis.

1.1 Structure of the Paper

The paper is structured as follows. Firstly, a literature review describes the general impact and economic consequences of the Russian full-scale invasion of Ukraine on the global economy. Secondly, it unveils why Ukraine turned out not to be ready

for the military aggression of the Russian Federation in 2014 and was not able to prevent it or be maximally prepared for the aggression in 2022. Thirdly, the economic impact of the Russian invasion of Ukraine on the global trade of agricultural commodities is described by analysing global trade data. Finally, the findings are discussed in the light of actual and possible political and economic stimulus measures, and conclusions are drawn regarding how to ameliorate the impact of market disruptions on import countries of Ukrainian agricultural commodities.

1.2 Methodology

The objective of the study is to assess the impact of the war in Ukraine on the global trade of agricultural products as a basis to design possible strategic measures to re-establish full participation of Ukraine in global trade. To achieve the stated purpose, the method of systematic analysis and comparison (to analyse the structural changes caused due to processes under study) is applied.

The methods used in the research are aimed at defining the degree of interconnection between the consequences of the war in Ukraine and the global trade and global GDP indices. To do so, Pearson correlation coefficient (*cor*) based on several significant suppositions has been calculated. Firstly, it is considered that the analysed variables have normal distribution and they have a linear interconnection. Secondly, should there be no connection between the variables when they vary independently, the value of the correlation coefficient equals null ($r = 0$). The stronger the connection between the variables, the closer the value of the correlation coefficient is to 1. Positive values of r indicate a positive (direct) connection, while negative values indicate a negative (reverse) connection. Along with the Pearson correlation coefficient, a number of degrees of freedom (*df*) and *p*-values were calculated in the research (Vitlinskyi et al., 2014).

To range factors of changes in the global trade, which were caused by the Russian aggression against Ukraine, a multiple regression model was built using the function *lm()* in programming environment *R*, which is used for statistical calculations. The multiple regression model enables defining dependence between the variables and forecasting the value of a dependent variable based on the independent factors.

The formula of the multiple regression model is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p + \varepsilon,$$

where

– *Y* is a dependent variable that we are attempting to predict;

- $X_1, X_2, \dots, X_p$ are independent variables that affect the dependent variable;
- $\beta_0, \beta_1, \beta_2, \dots, \beta_p$ are regression coefficients that reflect the impact of the independent variables on the dependent variable and
- ε is a model error that represents a non-random fraction of observations that is not explained by the independent variables.

The aim of the regression model is to estimate regression coefficients ($\beta_0, \beta_1, \beta_2, \dots, \beta_p$) and to use these coefficients to predict the values of the dependent variable Y based on the input values of the independent values ($X_1, X_2, \dots, X_p$). While building the model, the function *step()* was used to select the least significant factors that do not have considerable impact on the explanatory variable. This selection provides a more accurate and significant model. The modelling resulted in obtaining a number of coefficients, and based on their values, the value of the dependent variable can be forecasted. Major indices obtained from calculating function *lm()* are as follows:

1. Intercept (a point of intersection of lines with the coordinate axis or interception): This value indicates where the regression line crosses axis y if $x = 0$. It is calculated using the formula:

$$\text{Intercept} = \beta_0$$

2. R -squared (determination coefficient): This index measures the proportion of explanatory variables that may be explained by independent variables in the model. It is calculated using the formula:

$$R - \text{squared} = 1 - \frac{\text{SSR}}{\text{SST}}$$

where SSR is the sum of squared residuals of the model and SST is the sum of squared deviations from the average value of the explanatory variable.

3. Adjusted R -squared (corrected determination coefficient): This index accommodates a number of independent variables and a size of selection for more accurate estimation of model forecast. It is calculated using the formula:

$$\text{Adjusted } R - \text{squared} = 1 - \frac{(1 - R^2)(n - 1)}{n - p - 1}$$

where n is the number of observations and p is the number of independent variables.

4. F -statistics (statistics F): This index is used to estimate the significance of the regression model on the whole. It is calculated using the formula:

$$F - \text{statistic} = \frac{(\text{TSS} - \text{RSS})/p}{\text{RSS}/(n - p - 1)}$$

where TSS is the sum of squared deviations from the average value of the explanatory variable and RSS is the sum of squared residuals of the model.

5. t -value (criterion of Student's t -distribution): This index is used to estimate the statistical significance of each regression coefficient. It is calculated using the formula:

$$t - \text{value} = \frac{\beta}{\text{SE}(\beta)}$$

where β is the coefficient estimation and $\text{SE}(\beta)$ is the standard estimation error.

6. p -value: This index indicates the statistical significance of each regression coefficient. It is calculated by comparing the t -value and the corresponding Student's t -distribution and by defining probability to receive more extreme indices.

Additional tests to check the model suppositions, including normality of distribution residuals (using the Shapiro–Wilk test) and autocorrelation (using the Durbin–Watson statistic), were carried out. The Shapiro–Wilk test is used to check the hypothesis regarding the normal distribution of model residuals. In this test, W is calculated based on the residuals order statistic and is compared with theoretical distribution, which is considered normal. The p -value of the test demonstrates how serious the deviation of the observed data is from the normal distribution. If the p -value exceeds the established level of significance, the hypothesis about normal distribution is not rejected. The Durbin–Watson statistic is used to check for autocorrelation in the model residuals. This statistic is based on comparing adjacent residuals, and it estimates the degree of lineal dependence between them. The value of the Durbin–Watson statistic varies between 0 and 4. A value close to 2 indicates the absence of autocorrelation, a value under 2 indicates positive autocorrelation and a value over 2 indicates negative autocorrelation. Both tests use input data (model residuals) to calculate statistics and to compare them with statistical distribution. Statistical values are compared with an established significance level, so as to draw a conclusion concerning distribution normality.

and autocorrelation in model residuals. Therefore, the built regression model and calculation of these indices let us estimate the impact of the factors on the variable and forecast values of the dependent variable based on this model.

2. Background: Economic Consequences of the Russian–Ukraine War on the Global Economy

Many countries have already experienced serious economic consequences of the Russian full-scale invasion of Ukraine. Russia and Ukraine are major exporters of agricultural products and fossil fuels; therefore, hitches in the supply of these goods and resulting price hikes are being observed all over the world. Since the countries of the Black Sea region are significant exporters of fertilisers, deficit and price hikes may lead to a decrease in agricultural yields in many regions of the world. This, in turn, may lead to higher volatility of food prices (World Food Programme, 2022).

The issue of price formation stability and application of various regulating tools for agricultural key commodities, on which securing global food security directly depends — especially low-income, food-deficient countries (FAO, 2021) that are net importers of agrarian products — is a core aspect on the agenda of leading international organisations and formal groups such as the World Trade Organisation (WTO), UN Food and Agriculture Organisation (FAO), International Grains Council (IGC) and Cairns Group. FAO data estimate that more than 251 million people in these countries are severely food insecure (Vickers et al., 2022).

FAO (2022b) has monitored global food price levels since the 1990s. In March 2022, experts of the organisation recorded food prices peaking around the world. The prices increased by over 12% compared to previous months and by over 30% compared to a similar time period in the previous year (March 2021). In April 2022, the FAO food price index was equal to 158.2 points on average, which is 0.8% lower than in March 2022, but is still about 30% higher compared to a similar time period of the previous year (April 2021) (FSIN, 2022). This, in turn, means that people, particularly in the least developed countries (LDCs), struggle with food prices, because a significant part of their income was spent on food already before COVID-19 and the Ukrainian war. The World Bank estimates the average share of household expenditures in developing countries spent on food to be between 50% and 60%, but in some of the poorest countries, it can be as high as 80%. For example, in South Asia, it

was 52.7% and in Sub-Saharan Africa, it was 61.9% (World Bank, 2023a, 2023b). It is important to state within this context that Ukraine has a sufficient reserve of food products to fully satisfy global demand.

According to the World Bank forecast concerning product markets, the cost of many food products will soar. The UN food price index affirms that costs have peaked since the start of its calculation 60 years ago. At the same time, according to expert predictions, wheat prices will rise by over 40% (World Bank, 2022c), reaching a record level in its nominal value in 2022.

Over the last three decades, countries of the Black Sea region have become key global suppliers of grains, oil crops and vegetable oil. Ukraine and the Russian Federation are among the world's seven largest producers and exporters of wheat, corn, barley, sunflower seeds and sunflower oil. A major part of these products is supplied to countries of northern Africa and the Near East, as well as to European countries and China, in the case of corn originating from Ukraine. Ukraine is a large sunflower oil supplier and provides over half of the global production of this product. In 2019, Ukraine and the Russian Federation covered 25% of the global wheat export volume and 14% of the corn export (UN Comtrade Database, 2023).

3. Results and Discussion

3.1. Economic Effects of the War in Ukraine on the Global Trade of Agricultural Products

Uncertainty about the duration and geographical scale of the war causes intensification of fluctuating changes within the global agricultural production system. Currently, several direct and indirect consequences of the Russian invasion of Ukraine may be defined. The direct consequences include the considerable reduction in production and, consequently, export of both countries, destruction of infrastructure, decrease of human resources caused by mobilisation of the population to the military, etc. Among the indirect consequences are the economic sanctions introduced by the international community towards the Russian Federation, the aggressor country. The sanctions aim to shorten the duration of the war, and even though the scope and reach of them is unprecedented since World War II, it is unclear if they will succeed to bring the conflicting parties to the negotiation table (Mulder, 2022). Sanctions have some flaws: first, the time lag between measures and visible impact on the Russian

economy; second, the fact that embargos are not being enforced by over 100 countries representing 40% of world GDP; and third, the retaliation from Russia by threatening the supply of gas and oil to Europe. The European dependence on Russian fossil fuels is a painful reminder of the lack of strategic foresight of European economic policy, which some might see is characterised by geopolitical naivete (The Economist, 2022).

The above-mentioned events will result in a decrease in GDP within the countries taking part in the conflict as well as outside, particularly European countries, considering their close geographical proximity to the region and their dependence on Russian energy resources, which may destabilise their political systems. It is expected that the world GDP will grow by only 2.8% in 2022 in terms of market currency rates compared to the increase by 5.7% in 2021. However, long-term effects may be graver. In particular, there is a risk of further aggravation of fluctuation processes, limiting competition, and reduction of innovations within the global economic system, which may lead to a decrease in the world GDP by 5% in the long-term perspective (WTO, 2022b). In addition, according to experts' assessment, in 2022, the war will have greater impact on global trade rather than on the global GDP. To estimate the degree of influence of the war in Ukraine on major indices of the global economic system, a series of correlation coefficients was calculated (Table 1).

While carrying out the correlation analysis, the index of cereal production in Ukraine was taken as an independent variable since the country is one of the key exporters to the international agricultural market. As a result (Table 1), the correlation between the world GDP and international trade fluctuation (0.81) and production volumes of the mentioned produce (0.75) was calculated. In addition, greater manifestation of war consequences in Ukraine will be observed in global trade. Forecasts estimate a decrease in growth to 1% in 2023, down sharply from the previous estimate of 3.4% (WEF, 2022; WTO, 2022a, 2022c). It is important to note that the growth rate of global trade could be influenced by many factors, including economic conditions, political developments and changes in trade policies, among others. These figures may be reconsidered due to the indeterminacy of the conflict development in Ukraine. Therefore, on the global scale, a consequence of the Russian–Ukrainian War is a tendency of growth rates slowing down production processes as well as trade turnovers within the Ukrainian and international agricultural product sectors. Simultaneously, in the near term, trade costs will rise due to export limitations, logistics failures, the high cost of energy sources, etc.

As a result of these circumstances, agricultural product supply failures have caused a drastic price hike. According to FAO food price indices (FFPI), international export quotations of major foods have been growing since the second half of 2020 almost uninterruptedly. This ascending tendency climaxed in March 2022, when they reached their historical maximum (Fig. 1).

At the same time, the global markets of cereals and vegetable oil are those that suffered most from the price hike (FAO, 2022c). Particularly, wheat cost has risen by over 40% since the war started (herewith, futures prices have increased by over 60%) (European Commission, 2022). Prices for foods such as rice and corn have acquired a similar tendency due to production hitches and because these goods are a wheat substitute. Cereal and vegetable oil prices continued growing during the first 5 months of 2022. As for wheat, prices grew in March due to shortened export stocks before the harvest of 2022–2023. The situation has been further deteriorating due to Ukrainian export failures because of the logistics crisis (FAO, 2022d). Global prices for different kinds of meat have similarly risen. Poultry meat has undergone the highest price rise, since its supply in the global market is limited too due to the war in Ukraine and bird flu outbreaks. Even though prices slightly decreased over the following 2 months, quotations of all product groups in FFPI remain high. Higher food prices mostly affect countries with low- or medium-income levels in Africa, southwards from the Sahara Desert (Botswana, Zimbabwe) and in the Near East (Algeria, Tunis), intensifying the poverty and food crisis issue in the world (WTO, 2022b).

Based on the multiple regression method, considerable dependence of global food prices on the volumes of production and export of major kinds of agricultural products from Ukraine was computed (see Table 2). The model uses several independent variables (provided in Table 2 in the indices column, except for dependent variables), which were used to calculate the degree of dependence of a dependent variable (food price index [normal] in one case and supply world cereal market [million t] in the other). To level the ability of determination coefficient R^2 to increase along with several variables in the regression model, the adjusted determination coefficient (adjusted R -squared) was calculated. As a result, food price index (normal) appeared to have a high degree of density of connection and supply world cereal market (million t) appeared to have a moderate degree of density of connection. According to the residual standard error (RSE) index, the model meets the data more accurately in the case of calculations for food price index (normal).

Table 1. Impact of the war in Ukraine on the global GDP and global trade
Tabelle 1. Auswirkungen des Ukrainekriegs auf das globale GDP und den globalen Handel

Indices	The original computing data								
	Years								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross domestic product: World, million US dollars	77,097,370.2	78,991,149.9	74,598,693.1	75,812,114.3	80,640,541.5	85,748,800.5	87,106,406.7	84,659,888	96,100,091
Merchandise exports by product group: world, annual, million US dollars	18,959,331	19,005,917	16,556,508	16,039,355	17,742,592	19,546,006	19,004,555	17,645,180	22,283,819
Production of Ukraine: total cereals, million t	62.9	63.65	59.94	65.53	60.83	69.29	74.73	64.61	85.62
Computing results (Pearson's product-moment correlation)									
Data:	Sample estimates: cor					Other computing parameters			
Gross domestic product (million US dollars, world) to production Ukraine total cereals (million t)	0.7527341					$t = 2.8008$, $df = 6$, $p\text{-value} = 0.03113$ alternative hypothesis: true correlation is not equal to 0 95% confidence interval: 0.1023517–0.9522851			
Merchandise exports by product group world (annual, million US dollars) to production Ukraine total cereals (million t)	0.8050335					$t = 3.5904$, $df = 7$, $p\text{-value} = 0.008853$ alternative hypothesis: true correlation is not equal to 0 95% confidence interval: 0.3028017–0.9573287			

Source: Own calculations based on AMIS (2022), World Bank (2022b) and FAO (2022b)

A similar model was built for cereal supply within the global market. Its results enable us to state the presence of a direct connection with the last index.

Having used the mentioned data and the regression model in the first formula, we obtained the following outcomes: the value of multiple R -squared equals 0.9613 and the value of adjusted R -squared equals 0.9381. It means that the model used in the regression analysis accounts for 96.13% (or 93.81% considering the number of predictors) of variation in food price index (normal). RSE equals 3.212. It measures the volume of residual distribution around the regression line. The less the value of the standard error is, the better the model explains input data variation. The F -statistic equals 41.41 with 3 and 5 df . It is used to estimate the model significance on the whole. The p -value for the F -statistic equals 0.0005916, which is under the established significance level of 0.05. It means that there is statistically significant proof that at least one of the predictors is significant in the model. The outcomes of the Shapiro–Wilk test on residual

distribution normality demonstrate that the W -statistic equals 0.955, and the p -value is 0.7449. The p -value exceeds the established significance level of 0.05, which means that there is no valid proof of rejecting the null hypothesis about normal residuals distribution. The Durbin–Watson statistic value equals 2.62. The value is close to 2, which demonstrates the absence of significant autocorrelation in model residuals. Summing up, the model has a high determination coefficient, which means that it perfectly explains the dependent variable. There is also no proof of deviation from residuals distribution normality and the absence of autocorrelation.

As for the second formula, the following outcomes were obtained: the multiple R -squared value equals 0.7173 and adjusted R -squared is 0.6231. This means that the model used in the regression analysis accounts for 71.73% (or 62.31% considering the number of predictors) of variations in supply world cereal market. RSE equals 98.75. It measures the volume of residual distribution around the regression line. The less the value of the standard error is, the

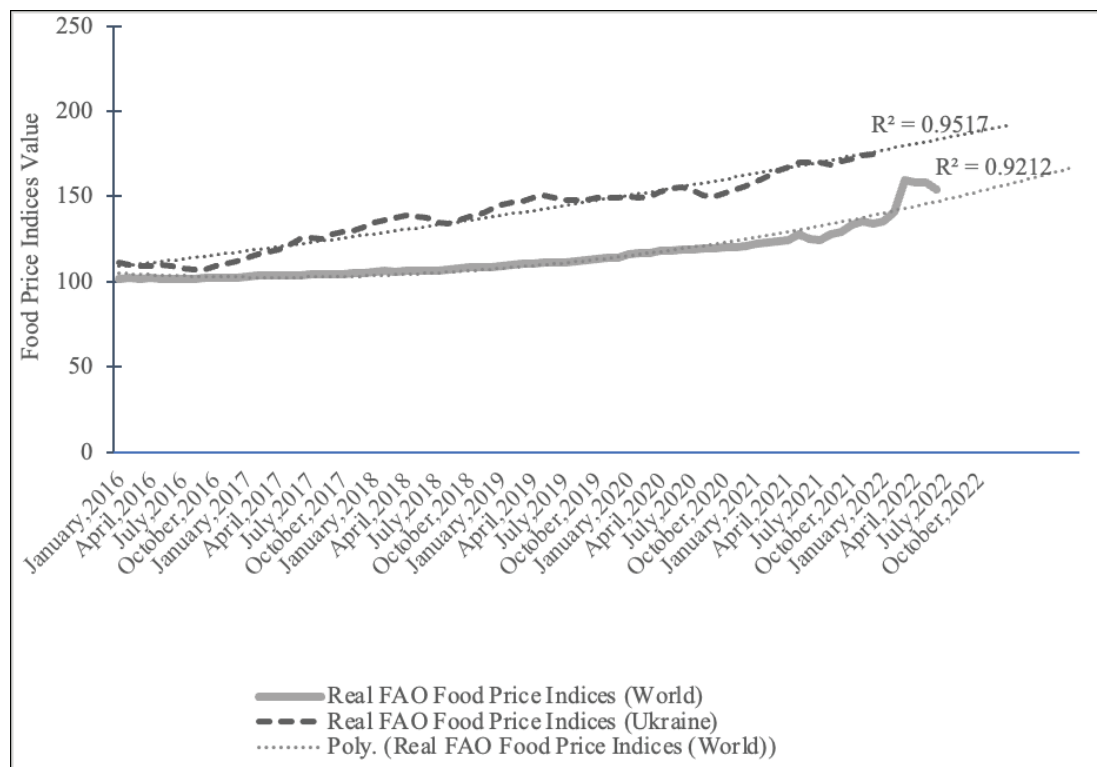


Figure 1. Development of the world and Ukrainian food price indices. Source: Own depiction based on WTO (2022b).

Abbildung 1. Entwicklung des FAO Welt-Lebensmittelpreis Index und des FAO Ukraine Lebensmittelpreis Index. Quelle: Eigene Darstellung basierend auf WTO (2022).

better the model explains input data variation. The F -statistic equals 7.613, with 2 and 6 df . The p -value for the F -statistic equals 0.02258, which is under the established significance level of 0.05. This means that there is statistically significant proof that at least one of the predictors is significant in the model. The outcomes of the Shapiro–Wilk test on residual distribution normality demonstrate that the W -statistic equals 0.94661, and the p -value is 0.653. The p -value exceeds the established significance level of 0.05, which means that there is no valid proof of rejecting the null hypothesis about normal residuals distribution. The Durbin–Watson statistic value equals 1.92. The value is under 2, which may indicate the presence of positive autocorrelation in model residuals. Summing up, the model has a moderate determination coefficient, which means that it explains part of the dependent variable variation. Residuals distribution normality has not been rejected, but positive autocorrelation may be present. It must be taken into account that the research used limited data of a particular time period. It might limit generalising outcomes in other time periods or in other contexts. The regression model involves some suppositions, such as lineal dependence between variables, residuals independence, and

normal residuals distribution. These suppositions may not be fulfilled perfectly, which might affect the accuracy of the outcomes. Moreover, the model does not include all possible factors that may influence a dependent variable. Other factors not considered might have an impact on the relationships between variables and result in a change of outcomes. Despite the relatively small Ukrainian share in general volume of the global trade and production (Table 3), its integration into international agricultural markets is considerable. The Ukrainian agrarian sector is a powerful exporter of agricultural products with several items, including major foods. According to Ukrainian customs statistics, in 2020 compared to 2019, agrarian sector product export accounted for 22.9 billion USD, which is higher by 0.2%, while import accounted for 6.9 billion USD, which is higher by 13.2%. In other words, the surplus of foreign trade balance decreased by 4.3%. In 2020, the share of agricultural commodities in Ukrainian export of all products accounted for 47%, which is more by 0.9 p.p. compared to 2019 (UKRSTAT, 2022). In 2018–2020, Ukrainian export of sunflower seeds, corn, and wheat accounted for 38%, 10.6%, and 7.2%, respectively, within the global market (Ukraine took the first, fourth, and

Table 2. Results of multiple regression analysis of war consequences in Ukraine for global food price index and global supply market of cereals
Tabelle 2. Ergebnisse der multiplen Regressionsanalyse zu Auswirkungen des Ukrainekriegs auf den Lebensmittelpreisindex

Indices	Original computing data								
	Years								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Food price index (normal)	120.13	115.03	93.05	91.92	98.02	95.92	95.10	98.13	125.73
Supply world cereal market, million t	3,149	3,279	3,353	3,455	3,518	3,501	3,545	3,604	3,644
Exports Ukraine total cereals million t	62.9	63.65	59.94	65.53	60.83	69.29	74.73	64.61	85.62
Exports Ukraine wheat million t	9.73	11.25	17.42	18.1	17.75	15.94	21.03	16.83	19
Production Ukraine total cereals, million t	62.9	63.65	59.94	65.53	60.83	69.29	74.73	64.61	85.62
Computing outcomes (multiple regression)									
Data:	Multiple <i>R</i> -squared (adjusted <i>R</i> ² -squared):		Other computing parameters						
<i>lm</i> (formula = food price index [normal] ~ production Ukraine total cereals, million t + exports Ukraine total cereals million t + exports Ukraine wheat million t, data = data)	0.9613 (0.9381)		Residual standard error: 3.212 on 5 degrees of freedom (one observation deleted due to missingness) <i>F</i> -statistic: 41.41 on 3 and 5 DF, <i>p</i> -value: 0.0005916, Shapiro–Wilk normality test: data: Supply_fit\$residuals <i>W</i> = 0.955, <i>p</i> -value = 0.7449 Durbin–Watson statistic: 2.62						
<i>lm</i> (formula = supply world cereal market, million t ~ exports Ukraine total cereals million t + exports Ukraine maize, million t, data = data)	0.7173 (0.6231)		Residual standard error: 98.75 on 6 degrees of freedom (one observation deleted due to missingness) <i>F</i> -statistic: 7.613 on 2 and 6 DF, <i>p</i> -value: 0.02258, Shapiro–Wilk normality test data: Food_fit\$residuals <i>W</i> = 0.94661, <i>p</i> -value = 0.653 Durbin–Watson statistic: 1.92						

Source: Made by the authors. Original data (AMIS, 2022; FAO, 2022b; World Bank, 2022b).

fifth place in the exporter rating, respectively). In 2021, the given tendencies strengthened (Table 4), and such a trend was supposed to remain.

In the 2020–2021 marketing year, Ukraine produced a third of the global sunflower oil, nearly half of its global export, and two-thirds of sunflower meal (Table 5). However, as of 2022, after the full-scale invasion of Ukraine began, the number of export and import deals considerably decreased compared to the similar time period in 2021 (UKRSTAT, 2022). Before 1 March 2022, Ukraine had dispatched around 61% of the forecasted export of sunflower oil of 2021–2022. As for rapeseed, soy seed, and corn, Ukraine is the sixth largest producer (the ninth for soy) and the third, seventh, and fourth largest exporter, respectively. As of March 1, Ukraine managed to dispatch about 65% of the forecasted soy export and 80% of corn from the general planned volume in the 2021–2022 marketing year. Before the Russian full-scale invasion of Ukraine, Ukrainian sunflower oil had taken the highest specific weight in the import cost of EU countries

(24% of the general EU import from Ukraine), while corn (24%) and rape (15%) followed. As a quantitative indicator, the Ukrainian share in the EU import had reached 87%, 53%, and 35%, respectively. In March 2022, the import of these three products to EU decreased by 10% (sunflower oil), 37% (corn), and 29% (rape), respectively, compared to the same time period in the previous year. Ukraine is the seventh largest wheat producer in the world and, as it is predicted, would become the fifth largest exporter in the 2021–2022 marketing year (FAS, 2022b).

Generally, in 2020, major Ukrainian partners in agrarian and food product export were China (16% of the general export volume of Ukrainian agricultural products), India (6.7%), the Netherlands (6.4%), Egypt (6.2%), Turkey (4.8%) and Spain (4.4%). Concerning imports to Ukraine, the major partners were Poland (11.3% of the general import volume of Ukrainian agricultural products), Italy (7.3%), Turkey (7.3%), Germany (6.9%), the USA (4.4%) and the Netherlands (4.2%) (Table 5). At the same time, countries that

Table 3. The development of the world and Ukrainian volumes of agricultural trade for export and import
Tabelle 3. Entwicklung des globalen und ukrainischen Handelsvolumens

Indicator	Merchandise import by product group – annual (millions, USD)							2020–2015, %
Reporting economy	Product/sector	2015	2016	2017	2018	2019	2020	
World	Total merchandise	16,737,067	16,210,510	17,996,159	19,840,118	19,316,692	17,871,990	107
World	Agricultural products	1,599,244	1,604,023	1,766,106	1,856,514	1,827,560	1,849,613	116
World	Food	1,344,459	1,358,280	1,488,549	1,556,537	1,553,561	1,601,522	119
Ukraine	Total merchandise	37,517	39,252	49,609	57,188	60,800	54,337	145
Ukraine	Agricultural products	3,805	4,262	4,742	5,512	6,167	6,892	181
Ukraine	Food	3,377	3,774	4,159	4,903	5,576	6,327	187
Ukraine/World	Total merchandise	0.22	0.24	0.28	0.29	0.31	0.30	136
Ukraine/World	Agricultural products	0.24	0.27	0.27	0.30	0.34	0.37	157
Ukraine/World	Food	0.25	0.28	0.28	0.31	0.36	0.40	157
Ukraine	Agricultural products/ total merchandise	10	11	10	10	10	13	125
Indicator	Merchandise export by product group – annual (millions, USD)							2020–2015, %
Reporting economy	Product/sector	2015	2016	2017	2018	2019	2020	
World	Total merchandise	16,556,508	16,039,355	17,742,592	19,546,006	19,004,555	17,645,180	107
World	Agricultural products	1,564,085	1,584,129	1,725,209	1,804,030	1,779,888	1,803,125	115
World	Food	1,331,133	1,355,836	1,468,845	1,530,116	1,526,959	1,568,080	118
Ukraine	Total merchandise	38,127	36,360	43,265	47,336	50,054	49,192	129
Ukraine	Agricultural products	15,296	15,983	18,460	19,478	22,891	22,931	150
Ukraine	Food	14,476	15,218	17,704	18,520	22,020	22,089	153
Ukraine/World	Total merchandise	0.23	0.23	0.24	0.24	0.26	0.28	121
Ukraine/World	Agricultural products	0.98	1.01	1.07	1.08	1.29	1.27	130
Ukraine/World	Food	1.09	1.12	1.21	1.21	1.44	1.41	130
Ukraine	Agricultural products/ total merchandise	40	44	43	41	46	47	116

Source: Own calculations, based on FAO (2022b).

are currently most vulnerable to the described crisis are those importing domestic agricultural products, like Gambia, Lebanon, the Republic of Moldova, Djibouty, Libya and Tunisia, whose general wheat import from Ukraine reached over 40% (Ivchenko et al., 2021). These countries have a low income level per capita, since their population usually spends a greater part of its income on food compared to developed countries. Because of the great dependence on the import of domestic products and considerable volatility of domestic markets, they may encounter challenges of rapid transition to alternative export sources, which will likely lead to a delivery deficit in the short-term perspective. Ukrainian wheat production and export hitches determine particularly high destabilising risks in this segment, considering the pre-war production and trade volumes.

Countries that directly depend on food imports from Ukraine need to find other suppliers as soon as possible.

In the long term, to guarantee food security to their population, such countries should pay attention to diversifying their imports and their domestic production. Moreover, the international community must pay attention to existing potential long-term challenges concerning global growth and cooperation and set measures to counteract the world being 'separated' by the aggressor country.

Therefore, the war in Ukraine has caused further destabilisation of the global agrarian markets in times of already highly volatile international product and raw material prices. Considering favourable weather conditions and some growth of production facilities of the Ukrainian agrarian sector, potentially, 2022 was supposed to deliver high yields of cereals, accordingly maintaining a high level of export opportunities. However, military actions in Ukraine and invasion of a considerable part of its territory provoked several negative factors, particularly the relocation of population, damage and

Table 4. The rank of Ukraine among the largest international producers and exporters of agricultural products (2021–2022 marketing year)
Tabelle 4. Rang der Ukraine unter den global größten Produzenten und Exporteuren landwirtschaftlicher Produkte

Product		Value (billion \$)	Volume (1,000 MT)	Rank among global producers/exporters	% of global production / exports	Top markets
Corn	Production		41,900	#6	3.50%	China \$1.9B, EU \$1.8B, Egypt \$0.5B
	Export	5.9	23,000	#4	12%	
Wheat	Production		33,000	#7	4.30%	Egypt \$0.9B, Indonesia \$0.7B, Turkey \$0.4B
	Export	5.1	19,000	#5	9%	
Barley	Production		9,900	#4	6.80%	China \$0.7B, Turkey \$0.2B, Saudi Arabia \$0.1B
	Export	1.3	5,800	#3	17%	
Sunflower	Production		17,500	#1	30.60%	
	Export		75	#9	3%	
Sunflower Oil	Production		5,676	#2	30.60%	India \$1.9B, EU \$1.9B, China \$0.9B
	Export	6.4	4,950	#1	46%	
Sunflower Meal	Production		5,452	#2	27.50%	
	Export		4,100	#1	54%	
Rapeseed	Production		3,015	#6	4.20%	EU \$1.1B, Pakistan \$0.2B, UK \$0.2B
	Export	1.7	2,700	#3	20%	

Source: Own calculations based on FAS (2022b).

destruction of civil infrastructure, limiting transportation of people and goods, which partially or fully froze the ability of farmers to act normally, harvest and sell their harvest. The situation has further deteriorated due to interruptions in infrastructure and institutional provisions. After the active military actions moved to the eastern and southern parts of the country at the beginning of April 2022, economic activity, particularly agricultural activity, in the central, northern and some southern parts of the country started to resume. In these areas, farmers started working in the fields, often facing a challenge to retrieve unexploded ammunition before applying fertilisers for winter crops or preparing soil for planting spring crops. These circumstances evoke serious anxiety about their potential negative effect on the food security within the country as well as at the international level.

3.2. Priority Directions to Overcome the Existing International Production and Trade Crisis in the Agricultural Production Sector as a Result of the Russian Full-Scale Invasion of Ukraine

For the international organisations to overcome damaging war consequences, countries' governments have developed and sent various kinds of aid to Ukraine. Particularly, substantial effort was made to handle logistical problems. Since

the beginning of the full-scale invasion and blockade of Ukrainian ports, through which about 90% of crops were shipped abroad, the issue of their export possibilities was aggravated. To solve the problem, negotiations started and alternative logistic supply chains were created, particularly through the seaports of neighbouring countries (i.e. Bulgaria and Romania). Through the mediation of Turkey, an agreement to create a safe export corridor in the Black Sea water area was signed 22 July 2022. At the same time, alternatives were created for blocked cereals to be transported from Ukraine. For the same reason, according to the agreement, some sanctions concerning cereal export from Russia were weakened too and a new net of storage facilities for agricultural products in Ukraine was created. In addition, considerable support has been directed to agricultural producers to stimulate crop production (USAID, 2022). This so-called 'grain agreement' signed separately by Ukraine and Russia on one side and representatives of Turkey and the UN on the other side (22 July 2022) foresees delivery of 20 t of grain that were stuck in Ukrainian Black Sea ports (Anon, 2022). Such an agreement can have a significant impact on global food security and help restrain the food price levels. The inability of Ukraine to export grain from its Black Sea ports has drastically decreased food supplies in countries in Africa and the Near East, which greatly depend on such imports.

Table 5. Product groups of Ukrainian export in 2020
Tabelle 5. Produktgruppen des ukrainischen Exports in 2020

Product group	Cost, million USD	Five major target markets, % of general cost of exported products to the given countries
Cereals	9,416.9	China (corn – 74.5%, barley – 25.3%), Egypt (wheat – 54.5%, corn – 45.4%), Indonesia (wheat – 99.4%), Spain (corn – 84.6%, wheat – 13%), the Netherlands (corn – 98.7%)
Oil crops	1,798.7	Germany (rapeseed – 72.5%, soy – 25%), Turkey (soy – 85.2%, rapeseed – 10.6%), Belgium (rapeseed – 99.5%), the Netherlands (rapeseed – 72.5%, soy – 25%), Belorussia (soy – 99.9%)
Vegetable oil	5,676	India (sunflower oil – 99.4%), China (sunflower oil – 87.2%, soy oil – 6.7%, rape oil – 6.1%), the Netherlands (sunflower oil – 99.5%), Spain (sunflower oil – 99.9%), Iraq (sunflower oil – 100%)
Meat and cold cuts	652	Saudi Arabia (meat and edible poultry by-products – 100%), the Netherlands (meat and edible poultry by-products – 99.9%), the UAE (meat and edible poultry by-products – 92.6%), Belorussia (meat and edible poultry by-products – 66.7%), Azerbaijan (meat and edible poultry by-products – 47.9%)
Milk and dairy products	172	Moldova (butter – 33.5%, cheeses – 24.3%), Kazakhstan (cheeses – 55.3%, butter – 19.1%), Georgia (condensed milk – 32.2%, butter – 38.4%), Azerbaijan (butter – 71.2%), China (whey – 75.9%)
Fish and fish products	42	Germany (filleted fish – 81.6%), Denmark (filleted fish – 88.5%), Japan (filleted fish – 100%), Lithuania (filleted fish – 53.2%), Belorussia (crustaceous – 99.9%)
Fresh vegetables	29	Poland (peppers, aubergines, pumpkins, etc. – 27.5%, cucumbers – 34.3%), Belorussia (tomatoes – 29.2%, cabbage – 34.1%), Moldova (tomatoes – 42.3%, carrots, beets, celery – 22.8%), Spain (beans – 99%), Romania (onions – 40.5%, peppers, aubergines, pumpkins, etc. – 39.1%)
Fresh fruit and berries	24	Poland (berries – 70.6%, melons, watermelons – 24.3%), Belorussia (apples, pears, quince – 54.1%, apricots, sweet cherries, etc. – 13.4%, berries – 11.8%), Moldova (melons, watermelons – 55.9%, apples, pears, quince – 22.5%), the Netherlands (berries – 95.2%), the UAE (apples, pears, quince – 90.3%)
Nuts, dried fruit, candied fruit	103	France (walnuts – 100%), Turkey (walnuts – 99.7%), Greece (walnuts – 100%), Azerbaijan (walnuts – 99.6%), Germany (walnuts – 89%)
Cocoa and cocoa products	201.4	Russian Federation (cocoa paste – 99.3%), Romania (chocolate – 100%), Belorussia (chocolate – 99.9%), Kazakhstan (chocolate – 99.9%), Bulgaria (chocolate – 100%)
Honey, sugar and sugar products	389	Poland (natural honey – 64.2%, confectionery without cocoa – 30.7%), Germany (natural honey – 69.5%, confectionery without cocoa – 30.4%), Romania (confectionery without cocoa – 59.2%, natural honey – 22.7%), Turkey (sugar – 52.6%, natural honey – 29.5%), Belorussia (confectionery without cocoa – 88%)

Source: Own depiction, based on Ivchenko et al. (2021).

The above-mentioned agreement will allow to partly reduce the pressure on grain exports from Ukraine and will avoid shortage in storage facilities. According to the data of IGC, Odessa and Black Sea ports are capable of exporting from 5 to 6 million tonnes of grain monthly, should they work at full capacity. Considering the current export power of 2.2 million tonnes, creating opportunities for extra trade channels through Black Sea ports would be enough to satisfy the needs of 7 million tonnes of export power (IGC, 2023), which is necessary to prevent a shortage in storage capacities; however, missile strikes in Odessa and Black Sea ports that followed the signing of the agreement caused serious infrastructure losses and considerably decreased the export capacity of these ports.

It must be mentioned that apart from the described efforts of the international community, any assistance to increase the opportunities of freer export of domestic products without tariffs or non-tariff barriers to foreign markets is highly important for Ukrainian industrial agriculture in

this complicated situation. In particular, Poland has accelerated undergoing customs procedures and Ukrainian product transportation, G7 countries fully support creating new selling chains by Ukraine, and Austria has lifted restrictions on Ukrainian carriers. Now, cargo traffic in Austria is available without any permits, which, along with previously lifted restrictions by Slovakia and Italy, enables Ukraine to deliver its agricultural products freely to Italy and its sea ports (Agravery, 2022). A number of international partners upgraded or developed programmes for supporting agrarian production in Ukraine. In particular, a plan for assessing the needs to reconstruct and restore Ukraine has been created by FAO (2022a) and the European Bank for Reconstruction and Development will facilitate credit resources to Ukrainian agrarian companies.

Along with support from abroad, which is already being given to Ukraine, the economic help provided by Ukraine itself is critically important. Particularly, the government lifted restrictions on volumes of state guarantees on a portfolio

basis on 15 March 2022 (KMU, 2022a) and the state programme of soft loans was broadened (KMU, 2022b).

So far, the Ministry of Agrarian Policy of Ukraine has decided that promoting oil crop exports is its top priority, considering their higher value and the fact that they cover logistical expenditures. At the same time, corn and wheat are likely to be stored in the country for 6–12 months (UGA, 2023). Considering this, the Committee on Finances, Tax and Customs Policy of Verkhovna Rada of Ukraine has recommended approving a bill on exemption from import duty taxation of goods used for storing grain and/or oil crops (# 7548-1) in the first reading of the bill and also generally (KMU, 2022c). It may be assumed that taking such measures will help Ukraine not to sell agricultural commodities at discount prices and save its products and functioning agrarian production in the mid-term perspective.

It must also be mentioned that the means for regional state administrations to grant subsidies have been increased. To create food security on the domestic market, the government of Ukraine implemented zero quotas on export of particular types of agricultural products on 5 March (Verkhovna Rada of Ukraine, 2022). Particularly, the export of living livestock, meat and meat by-products, buckwheat, wheat, sugar, barley, millet and some other items was banned. All these measures are aimed at protecting the majority of Ukrainian agrarians from defaults and to provide them with efficient volume of liquidity, whose full loss compensation is impossible in the short term. Many producers have currently fully halted their activity. However, the measures taken will help to provide food security in Ukraine and decrease the crisis effects for partnering countries.

Therefore, the Russian full-scale invasion of Ukraine led to several market disruptions for global trade of agricultural commodities and redistributed market power and supply infrastructure on the global agrifood market. In sum, this development weakened the position of countries of the Black Sea region that were leading exporters of agrarian products. Aiming at preventing famine, countries that participate in the global trade system have replaced tariff trade regulations with non-tariff measures to regulate trade volumes.

4. Conclusions

It is extremely difficult to predict the further course of events of the war against Ukraine and, accordingly, how global trade of agricultural commodities will be transformed. However, the longer the Russian war against Ukraine lasts, the more

complicated the situation will become for the Ukrainian agrarian sector and the national and global markets, potentially resulting in a new wave of global geopolitical and geo-economic instability. Food export hitches in Ukraine put global food markets at high risks, particularly for an increase of unfulfilled demand, volatile international food prices and worsening food crises in several countries. The war has led to a rise of prices for food, livestock feed, fertilisers, fuel, etc. The world has once again encountered a food and fuel crisis that so far has been mostly experienced by countries in Africa, Asia and the Middle East that import a great share of Ukrainian wheat. During nearly 6 months of the full-scale invasion, the whole economic ecosystem of the Ukrainian agricultural sector has experienced considerable losses along the whole chain, from fields to export markets. Currently, the following most damaging factors can be defined: substantial decrease in the quantity of agricultural land (due to the invasion as well as active military actions and mining by Russian invasive forces), destabilisation of the domestic market, destruction of infrastructure and logistical facilities, and stolen cereal and other stored agricultural commodities to further transport them illegally from the country and market them.

The above-mentioned logistics problems have limited the delivery of cereals to regular customers of Ukraine, such as countries in Asia or the Near and Middle East. Unblocking Ukrainian Black Sea ports can be a great opportunity to increase the export volumes of cereals and other agricultural products as well as all products of Ukrainian origin that are normally exported, particularly products of the iron and steel industry. The signed three-sided 'grain agreement' mostly covers logistics principles rather than rules on regulating trade of agrarian products. Despite all the measures for improving logistics, full transportation of cereals and oil crops is not possible within the desired time frame. Such export will be extended in time; therefore, Ukraine should search for opportunities to increase capacities for long-term storage of agricultural commodities.

References

- Agravery, 2022. The Ministry of Agrarian Policy is negotiating with European partners on financial support for agricultural producers. <https://agravery.com/uk/posts/show/minagropolitiki-vede-peremovini-z-evropejskimi-partnerami-sodo-finpidtrimki-agrovirobnikiv>.
- Amelin, A., 2022. The Ukrainian wartime economic strategy. *New voice*. <https://nv.ua/opinion/>

- pochemu-ukraina-okazalas-ne-gotova-k-voennoy-agressii-rossii-novosti-ukrainy-50233494.html.
- AMIS, 2022. Market database custom query. <https://app.amis-outlook.org/#/market-database/custom-query>.
- Barisitz, S., 1999. Ukraine: Macroeconomic development and economic policy in the first eight years of independence. *Focus on Transition* 2, 70-81.
- Borsellino, V., Schimmenti, E., El Bilali, H., 2020. Agri-food markets towards sustainable patterns. *Sustainability (Switzerland)* 12 (6), 2193.
- Demchak, I., Mytchenok, O., Trofimova, H., 2019. Foreign trade turnover of agricultural products. Ukraine, Kyiv: NDI "Ukrahropromproduktyvnist", 50.
- Democratic Initiatives Foundation, 2013. Public opinion in Ukraine. https://www.dif.org.ua/uploads/2013/01/opinion_january_2013_eng.pdf.
- The Economist, 2022. Are sanctions on Russia working? The lessons from a new era on economic warfare. The Economist. <https://www.economist.com/leaders/2022/08/25/are-sanctions-working>.
- European Commission, 2022. Monitoring EU agri-food trade: developments in March 2022. https://agriculture.ec.europa.eu/international/agricultural-trade/trade-and-international-policy-analysis/monitoring-eu-agri-food-trade-previous-editions_en.
- FAO, 2021. Low-income food-deficit countries (LIFDCs) - List updated June 2021. <https://www.fao.org/country-profiles/lifdc/en/>.
- FAO, 2022a. Assessing investment needs in Ukraine's agricultural reconstruction and recovery. <https://www.fao.org/3/cb9450en/cb9450en.pdf>.
- FAO, 2022b. FAOSTAT. Food and agriculture data <https://www.fao.org/faostat/en/#home>.
- FAO, 2022c. Food Price Index drops for the third consecutive month in June <https://www.fao.org/worldfoodsituation/foodpricesindex/en/>.
- FAO, 2022d. The importance of Ukraine and the Russian federation for global agricultural markets and the risks associated with the war in Ukraine. <https://www.fao.org/3/cb9013en/cb9013en.pdf>.
- FAO, IFPRI, WFP, 2022. Global report on food crises. <https://www.fao.org/3/cb9997en/cb9997en.pdf>.
- FAS, 2022a. Ukraine agricultural production and trade. <https://www.fas.usda.gov/sites/default/files/2022-07/Ukraine-Factsheet-July2022.pdf>.
- FAS, 2022b. Ukraine agricultural production and trade. Foreign Agricultural Service U.S. Department of Agriculture. <https://www.fas.usda.gov/sites/default/files/2022-04/Ukraine-Factsheet-April2022.pdf>.
- FSIN, 2022. Food Security Information Network. <https://www.fao.org/documents/card/en/c/cb9997en/>.
- Giordani, P., Rocha, N., Ruta, M., 2016. Food prices and the multiplier effect of trade policy. *Journal of International Economics* 101, 102-122.
- IGC, 2023. The International Grains Council (IGC). <https://www.igc.int/en/default.aspx>.
- ITC, 2022. Trade measures adopted in response to the war in Ukraine. <https://m.macmap.org/Ukraine>.
- Ivchenko, V. M., Mytchenok, O. O., Trofimova, H. V., 2021. Foreign trade turnover of agricultural production. Ukraine, Kyiv: NDI "Ukrahropromproduktyvnist", 36.
- KMU, 2022a. Ministry of Finance: Banks issued 5163 loans for about UAH 10.2 billion under state guarantees on a portfolio basis. <https://www.kmu.gov.ua/news/minfin-za-derzhavnimi-garantiyami-na-portfelnij-osnovi-bankami-vidano-5163-krediti-na-blizko-102-mlrd-grn>.
- KMU, 2022b. Changes to the program "Affordable Loans 5-7-9%": support for the sowing campaign and activation of entrepreneurship. <https://www.kmu.gov.ua/news/zmini-do-programi-dostupni-krediti-5-7-9-pidtrimka-posivnoyi-kampaniyi-ta-aktivaciya-pidpriyemnictva28032022>.
- KMU, 2022c. The Verkhovna Rada proposes to exempt from taxation imports of grain storage equipment. <https://www.kmu.gov.ua/news/minahropolityky-u-verkhovnii-radi-proponuiut-zvilnyty-vid-opodatku-vannia-import-obladnannia-dlia-zberihannia-zerna>.
- Malpass, D., 2022. A new global food crisis is building, Barron's. <https://blogs.worldbank.org/voices/new-global-food-crisis-building>.
- Mulder, N., 2022. Nicholas Mulder, who studies sanctions, declares a watershed. The Economist (March 4th 2022). <https://www.economist.com/by-invitation/2022/03/04/nicholas-mulder-who-studies-sanctions-declares-a-watershed-moment-in-global-economic-history>.
- Anon, 2022. Russia agrees to let Ukraine ship grain, easing world food shortage. New York Times, July 2022, <https://www.nytimes.com/2022/07/22/world/europe/ukraine-russia-grain-deal.html>.
- Semchuk, Z., Zharovskaya, I., Merdova, O., 2018. Corruption as a negative social phenomenon hindering the economic development of the state. *Baltic Journal of Economic Studies* 4, 295-300.

- UGA, 2023. Ukrainian Grain Association. Association of producers, processors and exporters of grain. https://uga.ua/news/treba-natsilyuvatis-na-dovgostrokove-zberigannya-zerna-visotskij/?fbclid=IwAR0g_QP1kDD1xxcSwM_8oMSfW_8EPy9p3km9mOSJyz5g8VbofRqnlPc9G2g.
- UIFuture, 2022. Analysis of the Ukrainian economy. <https://uifuture.org/publications/analiz-stanu-ukrayin-skoyi-ekonomiky/?fbclid=IwAR2w3mR1nXFW2nlZN9sf24S0U2y6ygrOWwSfFT8UpX4p020b78FOhpxZkyk/11.08.2022>.
- UKRCENSUS, 2020. Statistics of agriculture. <http://www.ukrcensus.gov.ua>.
- UKRSTAT, 2022. Express issue. Ukraine's foreign trade in goods in January-May 2022. http://ukrstat.gov.ua/metod_polog/metod_doc/2021/roz_zet/roz_zet.doc.
- UN Comtrade Database, 2023. Free access to detailed global trade data. <https://comtrade.un.org>.
- USAID, 2022. In the language of facts: the agricultural sector. <https://www.usaid.gov/node/453071>.
- Verkhovna Rada of Ukraine, 2022. Quota volumes of goods whose exports are subject to licensing. <https://zakon.rada.gov.ua/laws/show/1424-2021-%D0%BF#n24>.
- Vickers, B., Salamat, A., Balchin, N., 2022. The expanding threat to food security in least developed countries. <https://oecd-development-matters.org/2022/07/05/the-expanding-threat-to-food-security-in-least-developed-countries/>.
- Vitlinskyi, V.V., 2014. Economic and mathematical methods and models. Kyiv National Economic University, Kyiv, 221.
- WEF, 2022. These 3 charts show the impact of war in Ukraine on global trade. <https://www.weforum.org/agenda/2022/04/ukraine-war-global-trade-risk/>.
- World Bank, 2022a. Commodity markets outlook. <https://openknowledge.worldbank.org/bitstream/handle/10986/37223/CMO-April-2022.pdf>.
- World Bank, 2022b. World Bank open data. Free and open access to global development data. <https://data.worldbank.org/>.
- World Bank, 2022c. The impact of the War in Ukraine on global trade and investment. <https://openknowledge.worldbank.org/entities/publication/8a37c7fb-5fd8-56aa-bb7e-2a0970c468d9>.
- World Bank, 2023a. Living standards measurement study. <https://www.worldbank.org/en/programs/lsms>.
- World Bank, 2023b. World development indicators. <https://datacatalog.worldbank.org/search/dataset/0037712>.
- World Food Programme, 2022. Global report on food crises. May. <https://www.fao.org/documents/card/en/c/cb9997en/>.
- WSJ, 2022. Assessing investment needs in Ukraine's agricultural reconstruction and recovery. <https://www.wsj.com/livecoverage/russia-ukraine-latest-news-2022-03-25/card/ukraine-suffers-63-billion-worth-of->
- WTO, 2022a. Russia-Ukraine conflict puts fragile global trade recovery at risk. https://www.wto.org/english/news_e/pres22_e/pr902_e.htm.
- WTO, 2022b. The crisis in Ukraine: implications of the war for global trade and development. The World Trade Organization. https://www.wto.org/english/res_e/booksp_e/imparctukraine422_e.pdf.
- WTO, 2023. Trade growth to slow sharply in 2023 as global economy faces strong headwinds. https://www.wto.org/english/news_e/pres22_e/pr909_e.htm.
- Zarembo, K., Solodkyy, S., 2021. The evolution of Russian hybrid warfare: Ukraine. <https://cepa.org/comprehensive-reports/the-evolution-of-russian-hybrid-warfare-ukraine/>.