

## Correlation between the Greatest Agricultural Products Exporters to the EU: is Ukraine included?

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### Abstract

Due to the challenges we are experiencing nowadays, the importance of food security is gaining in its attention, making the subjects supplying agricultural production and ready-made food products more important and influential either economically or politically. The data under research are the agricultural products exports of Brazil, Canada, China, Ukraine, the United Kingdom and the United States to the European Union. The agricultural products are the goods from SITC (0+1) groups. The timeframe under analysis is eleven years – from 2012 to 2022 included. The purpose of the research is to assess whether the Ukrainian agricultural exports to the EU are correlated with the said exports of Brazil, Canada, China, the UK and the USA, and, if they are, how strong the correlation is. The comparative analysis of the dynamics, simple statistics, differences with the previous periods for the agricultural products exports of the analysed subjects to the EU was conducted. The trend lines for the analysed data during the given timeframe and two following years, were built using the appropriate function. The Pearson and Spearman correlation coefficients and their corresponding p-values were calculated and analysed.

### Keywords

Agricultural products exports, food security, EU, Ukraine, correlation.

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### Introduction

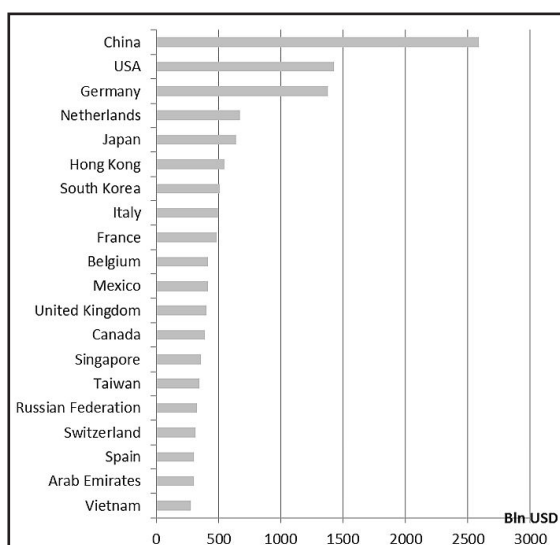
It is very interesting to read about the times of great changes and accomplishments in the historical chronicles, but the life is full of challenges, difficulties and the need to make fateful decisions every single moment in such times. We have such an exceptional opportunity to live through the times, which will surely be described as those of great challenges. It's hard to define the starting point of the times being talked about here. And many of those researching the topic would question the author's viewpoint, but the natural disasters indicating climate change are to be considered those bells the whole humanity should hear, comprehend and react immediately. Though there were certain attempts to make some steps towards the world industrial development alteration, they were not serious enough to make the necessary changes. And the humanity was forced to face another challenge – the COVID-19 pandemic. So, when talking about the challenges mentioned above, we can discuss the percentages

and possibilities of whether they were the reaction of the nature on the irresponsible behaviour of the whole humanity or its separate representatives, the next challenge we have to face nowadays is totally the responsibility of the ill behaviour of the people thinking not a single second about other human beings – it's war. But it's not the place and time to discuss trying to assess which of the said challenges is scarier and which should be reacted on as the first. The most important is that all of them threaten the most valuable thing we all have – life, directly or indirectly. And all of them made people think very hard about food security as food is necessary for human survival (Humboldt, 2018).

Being one of the indispensable sectors of the world economy, agriculture is not only one of the highest revenue earners worldwide, but also the one, which caters to the food requirement of the world (Dutta, 2020). Agriculture is one of the oldest industries which includes the primary sectors of farming, forestry, and fishery and aquaculture (Statista, n.d.).

A country that relies on its agriculture produce for its revenue generation is building a base to a strong economy (Dutta, 2020). The last statement is debatable as a country can be highly economically developed and politically influential being absent in the list of the greatest agricultural world producers.

The diversity of the climatic zones, weather conditions, landscapes, water proximity, etc. bring the quick and regular food supply to the fore. So, the agricultural products exporters start to play more and more important role in the economic and therefore political life of single countries, countries unions, continents and the whole world as well. And that is more than logical as food is vitally important for the survival of every single human being in particular and the whole world in general. In addition, it is not enough to produce much food in one or several taken countries, it is more important for every country to secure such an amount of food to ensure its population survival in any given situation. And that therefore means, it is important to find the reliable exporter/s to be able to supply the said amount of food. Let's see what countries are considered to be the leading exporters in 2020 (Figure 1).

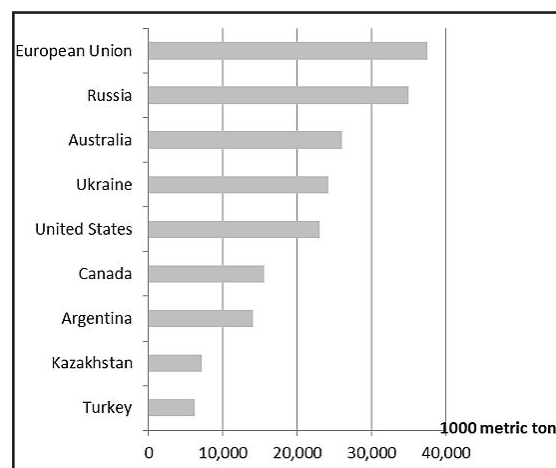


Source: author's elaboration on the basis of the data from Statista (2022(a)).

Figure 1: Leading export countries worldwide in 2020, bln USD.

What is interesting to notice in the list of countries presented in the figure given above, only the first two places are taken by the countries considered to be among the biggest ones in terms of their territories. The rest of the list can't be compared to the list of the biggest countries territorially. Another observation – the list is composed

of the countries, not the countries unions, so we won't see the EU here, though, six out of top 20 leading exporters in the world are country – members of the EU. One more noticeable fact is that we don't see such serious exporters as Brazil and Argentina in the list but we see Vietnam, the country which was not considered to be worth noticed as an exporter on the global level. Let's compare the list of the leading exporters with the one of the principal exporting countries of wheat, flour and wheat products (Figure 2).



Source: author's elaboration on the basis of the data from Statista (2022(a)).

Figure 2: Principal exporting countries of wheat, flour and wheat products in 2021/2022, 1000 metric tons.

As far as one can see, six out of top ten exporters of wheat and wheat products aren't included in the list of top 20 global exporters. These are Turkey, Kazakhstan, Argentina, Ukraine, Australia and Russia. But, attention should be paid at the fact, that, in Figure 2 either separate countries or countries unions are represented, such as the EU. Such a difference between the figures presented above has become the motivation of the research presented in this article. As you can see, either territorially big or relatively small countries are included in the second list but are not included in the first one. It means, that, on the one hand, the bigger the territory is the more land a country has for agricultural production. But, on the other hand, territory is not the only and main component of the agricultural production successful functioning.

Having dug through the literature sources available in the World Wide Web, the following observations are to be paid attention at – most scientists engaged into the topics connected with agriculture in general and the exports of agricultural products in particular, concentrate their research efforts

on the role of exchange rate volatility on Iran's agricultural exports, including the modern methods of quantitative risk analysis, specifically value-at-risk and expected shortfall approach, providing comprehensive and coherent risk evaluation throughout entire distribution of outcomes (Goudarzi et al., 2012), Albanian agricultural export with the help of the gravity model approach (Braha et al., 2017), African countries' agricultural trade value chain assessment being made on the example of the case study for Tanzania's cashew nut exports (Krepl et al., 2016), the impact of exchange rate volatility on the export of agricultural products (Jamalipour et al., 2016) as well as the long and short run and causal effects of real exchange rate volatility on agricultural products export in Nigeria (Alegwu et al., 2018), in addition the effects of exchange rate and foreign policies on Iranians dates export (Khalighi and Fadaei, 2017) plus impact of exchange rate volatility on the export of Thailand's key agricultural commodities to ASEAN countries (Jaroensathapornkul, 2021) and the effect of exchange rate volatility on agricultural products export price, the case study of Iran's saffron (Sabuhi-Sabouni and Piri 2008), analysis of the correlation between agricultural innovation ecosystem and economic growth (Xiaona, 2021), the correlation between the agricultural productivity and the export performance of the agro-food foreign trade in the Visegrad Group countries following accession to the European Union (Barath et al., 2010), agricultural exports analysis based on deep learning and text mining (Xu and Hsu, 2022), how energy consumption is related to agricultural growth and export: an econometric analysis on Iranian data (Raeni et al., 2019), potential impacts of free trade areas and common currency on sustainable agricultural export in Africa (Richardson et al., 2022), the effective factors on export of agricultural products and food industry of Iran with emphasis on competitiveness index of integrated real exchange rate (Abnar et al., 2020), the evaluation of the economic effects of exchange rate depreciation on the rice market in Iran (Mosavi et al., 2014), exporting out of agriculture: the impact of WTO accession on structural transformation in China (Erten & Leight, 2021), impact of agricultural export on inclusive growth in Nigeria (Taofik, 2017), causal relationship between agricultural exports and exchange rate: evidence for India (Ozdemir, 2017), a disaggregated analysis for Ghana's agricultural exports and economic growth (Siaw, 2018), the promotion of the agro-based export as engine of local economy in North-Sumatra, Indonesia (Tampubolon, 2018), export competitiveness

of agri-food sector during the EU integration process: evidence from the Western Balkans (Matkovski, 2021), the crop yields correlation with agricultural drought conditions (Puyu Feng et al, 2019), unobservable factors correlation with climate and agricultural outcomes (Shuai Chen and Binlei Gong, 2021), capital and credit constraints correlation with the other agricultural attributes (Twumasi et al., 2019), correlation between trade vulnerability and well-known economic parameters (Civin and Smutka, 2020), and others. As it can be seen from the literature review, the scientists research different aspects of the agricultural economy sector in general and agricultural products exports in particular within one country/country union. If, then, the matter of correlation/interaction is researched, the factors within the agricultural economy sector with each other or with the other economy sectors of the same country/country unions (analysed in a parallel way, that is without examining their correlation) are researched. Thereby, the knowledge gap consisting in the deficiency of the scientific publications researching the correlation between the agricultural products exporters, making stress on the correlation of the agro – exporters different in their territory and/or economy development level makes the research presented in the paper extremely topical and useful for the public administrators, big and small companies employees engaged in international trade in general and agro – exports in particular, decision makers of all the levels as well as representatives of the academic community. Therefore, the scientific questions to be answered in the course of the research are – should a territorially small country be considered a prominent player on the global agricultural market, should it be taken seriously into account and is it correlated then with the biggest market players? That leads us to the scientific hypothesis that even a territorially small country can be considered a prominent player on the global agricultural market, should be taken into account and is correlated with the other market players. So, the aim of the research is to answer the scientific questions mentioned above, proving/rejecting the presented scientific hypothesis, while assessing whether the Ukrainian agricultural exports to the EU are correlated with the said exports of such giants as Brazil, Canada, China, the United Kingdom and the USA, and, if they are, how strong the correlation is.

## **Materials and methods**

The data under research are the agricultural products exports of Brazil, Canada, China,

Ukraine, the United Kingdom of Great Britain and Northern Ireland (the UK), and the United States of America (the USA) to the European Union (the EU). The agricultural products are meant to be the goods from the SITC (0+1) groups. SITC means Standard International Trade Classification. Group 0 comprises food and live animals while Group 1 comprises beverages and tobacco. The SIT Classification has been chosen as, though the HS classification (Harmonized System) is rather popular among the researchers for being the World Customs Organization's Harmonized Commodity Description and Coding System (ITC, n.d.), the discrepancies appearing while trying to analyse the data from more than five – ten years make the research results a bit vulnerable as the mentioned classification system is being reviewed approximately once in five years with the new codes being added and some old ones being removed, that, in turn, urges the researchers to use the correlation tables of different HS versions. The data for analysis were taken from the Eurostat data base. The timeframe under analysis is eleven years – from the year 2012 to 2022 included.

The trend lines for the analysed data during the said timeframe and two following years, taken for the projection, were built using the appropriate functions, which were chosen from the exponential, linear, logarithmic, polynomial and power ones. The criterion for the choice of the right function was the values of the  $R^2$  coefficient. So, a basic exponential function is of the following formula:

$$f(x) = b^x \quad (1),$$

where ' $b$ ' is a constant and ' $x$ ' is a variable (Cuemath, n.d.(a)).

There are multiple linear function formulae to find the equation of a line depending on the available information, but the one used in the presented research is of the so-called slope-intercept form, which has the following formula:

$$y = mx + b \quad (2),$$

where  $(x, y)$  is a general point on the line, ' $m$ ' is the slope of the line and ' $b$ ' is y-intercept (Cuemath, n.d.(b)).

The equation for the logarithmic function is:

$$y = b \times \ln(x) + c \quad (3),$$

where ' $b$ ' is the slope and ' $c$ ' the intercept (XcelanZ, 2018).

The equation for a polynomial function of order 2,

used in the research, is as follows:

$$y = a_2 \times x^2 + a_1 \times x + b \quad (4),$$

where ' $a_2$ ', ' $a_1$ ' and ' $b$ ' are calculated parameters of the function (also named function coefficients or constants) that describe the relationship between ' $x$ ' and ' $y$ ' (Officetooltips, n.d.(a)).

The power function is calculated according to the following formula:

$$y = a \times x^b \quad (5),$$

where ' $a$ ' and ' $b$ ' are the parameters of the function found by the least squares method (also named function coefficients or constants) (Officetooltips, n.d.).

The correlation between the researched data sets was calculated by computing the Pearson and Spearman correlation coefficients. The Pearson correlation evaluates the linear relationship between two continuous variables (Minitab, n.d.). The formula for the Pearson's  $r$  is complicated, meaning it divides the covariance between the variables by the product of their standard deviations (Bhandari, 2021). Spearman's rho, or Spearman's rank correlation coefficient, is the most common alternative to Pearson's  $r$  (Bhandari, 2021). The Spearman correlation evaluates the monotonic relationship between two continuous or ordinal variables and is based on the ranked values for each variable rather than the raw data (Minitab, n.d.).

The research was conducted with the help of comparative and empirical analyses, as well as statistical one, including univariate and multivariate analyses. The research results are presented using such visualization tools as horizontal and vertical bar charts, line charts with markers as well as tabular method. The research itself as well as its results will be interesting and useful for the public administration bodies officials, big and small companies working either in the sphere of agriculture or international trade, decision makers of all the levels, academic community representatives as well as beginners and experienced data analysts.

## Results and discussion

Since the beginning of the so-called "special operation", Ukraine has been much spoken about. Politicians, journalists, experts from many activity spheres speak a lot of the geographical location of the country on the crossroads of European and Asian routes, of its geo-political location



between two political forces, of its available energy sources and its role in the trade flows of the said sources as a transit point, etc. Besides everything mentioned above, let's remember the place Ukraine takes as an agricultural producer. With the favourable geographical location and climatic conditions suitable for the agricultural production as well as having approximately 25% of the world's fertile soils, Ukraine has gained a prominent place among the biggest agro producers and exporters. The main agricultural products of Ukraine are sunflower seeds and oil, rapeseed, wheat, barley, maize, and soybeans. Though being not that big in terms of its territory on the global scale, being the second largest country in Europe, and not considered economically highly developed and therefore not among those most influential global players, Ukraine takes a prominent place among the agricultural producers of the global level. In 2020 Ukraine was the 14<sup>th</sup> top destination for the EU's agro – exports and the 4<sup>th</sup> agro – exporter for the EU (European Commission, 2021(a)). Though Ukraine lost some of its agricultural exports to the EU in 2021, it still remains on the fourth place among the largest exporters to the European Union (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2021). Before assessing whether Ukrainian agro – exports to the EU are correlated with the said exports of the biggest global agro – producers, let's have a quick look at their strengths in the agro – sphere.

The first country to compare is Brazil, a country of South America that occupies half the continent's landmass and is the fifth largest country in the world (Martins, 2022). The beautiful and modern cities, huge hydroelectric and industrial complexes, mines, and fertile farmlands make it one of the world's major economies (Martins, 2022). The main agricultural products Brazil is famous for as an exporter are soybeans and raw oil, corn, wheat, poultry (Brazil is the world's largest exporter of fresh chicken meat, responsible for about 14% of worldwide production and 30% of global exports) (Brazilian Farmers, 2022). The main destinations for the Brazilian agricultural exports in 2021 were China (20.9%), the European Union (16.3%) and the United States (9.8%) (Brazilian Farmers, 2022). In 2021, Brazil was the 13<sup>th</sup> largest partner for the EU exports of goods (1.6 %) and also the 13<sup>th</sup> largest partner for the EU imports of goods (1.6 %) (Eurostat, 2022).

Canada, situated in North America, is the second largest country in the world. But only 7% of the land in Canada can be farmed, the rest can

be used to ranch cattle. Among Canada's top agricultural products are canola, cattle and calves, beef and veal, vegetables and poultry (Hein, 2020). On the 21<sup>st</sup> of September 2017, the EU-Canada Comprehensive Economic and Trade Agreement (CETA) provisionally entered into force. In 2020, Canada was the 10<sup>th</sup> largest partner for the EU goods exports and the 16<sup>th</sup> largest partner for the EU goods imports (European Commission, 2021(b)).

China, a country in East Asia, is the third world's biggest country and the most populous one. China primarily produces rice, wheat, potatoes, tomato, sorghum, peanuts, tea, millet, barley, cotton, oilseed, corn and soybeans. In 2020 China was the largest exporter and the 2<sup>nd</sup> largest importer in the world. In 2021 China was the 3<sup>rd</sup> largest partner for the EU exports of goods (10.2 %) and the largest partner for the EU imports of goods (22.4 %) (Eurostat, 2022(a)).

The United Kingdom of Great Britain and Northern Ireland (UK), situated in north – western Europe, consists of the island of Great Britain, the north-eastern part of the island of Ireland and many small islands. The total area of the agricultural lands used in 2020 comprised 17.3 mln hectares, that is 71% of the whole territory of the country. The specialties of the United Kingdom agriculture are wheat, barley, vegetables, horticultural and livestock products (USDA, 2021). The EU is the UK's biggest trading partner, accounting for almost 50% of the United Kingdom foreign trade in goods in 2019 (48.1%). The UK is the EU's third biggest trading partner (12.6%) (European Commission, 2021(c)). In 2021, the United Kingdom was both the EU's largest export destination for agricultural products and the second largest origin of the EU imports, just behind Brazil (Eurostat, 2022(b)).

The United States of America (USA), a federal republic of 50 states situated in North America, is the fourth largest country in the world (Pessen, 2022). Due to the diversity of the climatic zones and conditions, many agricultural products are produced in the US, but, most of all, USA agriculture is famous for, among others, meat, soybean, corn, wheat, fruits, vegetables, and nuts. In 2021, the United States of America was the largest partner for the EU exports of goods (18.3 %) and the second largest partner for the EU imports of goods (11.0 %) (Eurostat, 2022(d)).

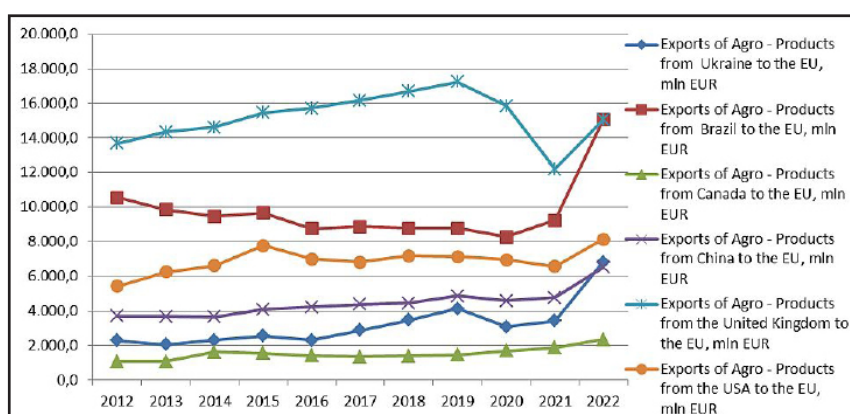
As an introduction to the research and in order to have a general overview of the analysed data, let's follow the dynamics of the agricultural products exports of Ukraine, Brazil, Canada, China,

the United Kingdom and the USA to the EU all in one figure (Figure 3).

The dynamics of all the agricultural products exports amounts are visualised in one figure given above to compare their amounts and dynamics easier. As far as we can see in Figure 3, the least amount of the agricultural products exports to the EU goes from Canada, the dynamics of which can also be called the most flat among the given ones. The agricultural products exports from Ukraine is the last but one as for their amount during the timeframe under analysis. The dynamics of the said exports can't be called flat, but its changes will be analysed further along the research. Another interesting observation is the opposite dynamics directions of the exports amounts mentioned above from the USA and Brazil in 2021, that is we observe the downward change of the said exports by the USA but an upward change by Brazil. One could make an assumption about a negative correlation between the countries' agro – exports, but that will be checked further along the research. The last but not the least, or, better to say the first

in terms of the exports amount, is the one of the United Kingdom. Besides being still the biggest in the amount, the agro – exports of the UK can be called the most changeable of all the ones under research, having a negative change in the year 2020 and a complete downfall in the following year. The decrease of the year 2020 by all the subjects except Canada can be explained by the impact of the COVID-19 pandemic. But such a sharp decrease of the UK agro – exports in the following year is nothing but the consequence of the Brexit, among the others. But, even more interesting is the changes of the agro exports amounts in the last year under research – all the analysed subjects experienced the increase of the said exports amounts.

Before assessing the presence/absence of the correlation between the subjects under research, let's compare the simple statistics of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU (Table 1).



Source: author's elaboration on the basis of the data from Eurostat (2022(c))

Figure 3: Dynamics of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU.

Variable	Minimum	Mean	Maximum	Sum	Standard Deviation
Agricultural Products Exports of Ukraine to the EU, mln EUR	2066.7 (2013)	3214.1	6824.1 (2022)	35355.1	1289.97171
Agricultural Products Exports of Brazil to the EU, mln EUR	8283.8 (2020)	9753.5	15042.3 (2022)	107288.1	1778.51131
Agricultural Products Exports of Canada to the EU, mln EUR	1076.7 (2012)	1534.2	2343.2 (2022)	16876.4	341.36733
Agricultural Products Exports of China to the EU, mln EUR	3657.7 (2014)	4449.1	6532.9 (2022)	48940.4	774.68446
Agricultural Products Exports of the United Kingdom to the EU, mln EUR	12195.7 (2021)	15178.2	17233.1 (2019)	166960.1	1362.63763
Agricultural Products Exports of the USA to the EU, mln EUR	5432.3 (2012)	6896.6	8143.8 (2022)	75863	690.18891

Source: author's calculations (Social Science Statistics, n.d.(c)) on the basis of the data from Eurostat (2022(c))

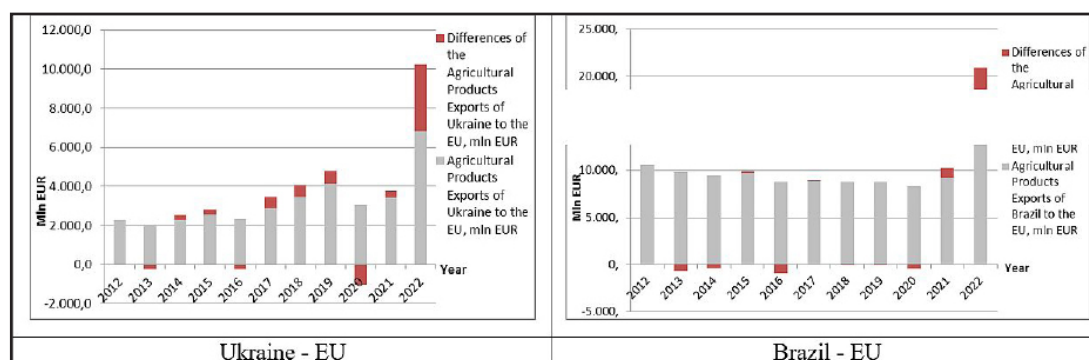
Table 1: Simple statistics of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU.

To make the analysis of the data presented in Table 1 clearer, the explanation of some abbreviations, used in it, should be given. These are: “Minimum” stands for the minimum value and “Maximum” stands for the maximum value of the observations analysed. In addition, the years, in which the maximum and minimum values stated in the table were noted, are indicated in brackets under the said values. If the list of the countries’ exports have been made according to their mean from the biggest to the smallest, the order of the countries would look like the data visualised in Figure 3, that is the biggest mean is by the agro-exports of the United Kingdom, then Brazil would come, followed by the USA, China, Ukraine and Canada. The mean of the Ukrainian agro-exports to the EU for eleven years under research is 4.7 times smaller than that of the United Kingdom, approximately 3 times smaller than that of Brazil, almost 2.2 times smaller than that of the USA, 1.4 smaller than that of China and approximately 2.1 times bigger than that of Canada. If we make the list of the countries’ exports according to their sums, minimum and maximum values, the list would look like the visual presentation of the data in Figure 3 and the list according to their mean values. Just for the comparison, the differences for the sum of the agricultural products exports values for the timeframe under analysis from Ukraine to the EU and all the other subjects under research are the same as the ones of the means. The minimum value of the agricultural products exports of Ukraine to the EU is 5.9 times smaller than that of the United Kingdom, approximately 4 times smaller than that of Brazil, 2.6 times smaller than that of the USA, almost 1.8 times smaller than that of China and 1.9 times bigger than that of Canada. The difference for the maximum value of the agro-exports of Ukraine to the EU and that of the United

Kingdom is 2.5 times in favour of the UK, with Brazil – 2.2 times in favour of Brazil, with the USA – 1.2 times in favour of the USA, with China – 1.05 times in favour of Ukraine and with Canada – 2.9 times in favour of Ukraine. Another observation draws anybody’s attention while analysing the maximum and minimum values of the subjects under research, meaning – if the minimum values were experienced by the researched countries in different years, the maximum values were seen in the same year by all the analysed subjects with the exception of the UK. A little bit different the list of the countries’ exports would outlook when we compose it judging by the standard deviation. That is, the first place will be still taken by Brazil, followed by the United Kingdom, but the third place is occupied by Ukraine, followed by China, the USA and Canada consequently. This, in turn, means, that the data of the Ukrainian agricultural products exports to the EU for the timeframe under analysis are more dispersed in relation to their mean than those of China and the USA, though taking place after them in terms of the said exports amount.

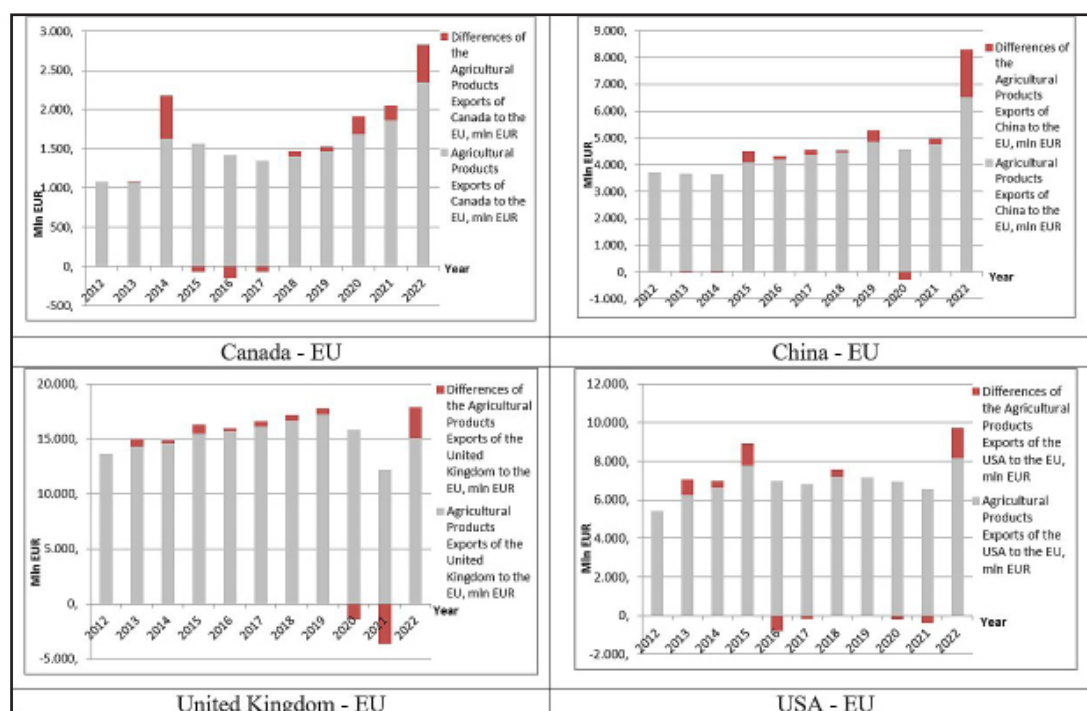
Deepening the research, let’s analyse the way the data values of the agricultural products exports of the subjects researched to the EU changed if compared to the previous periods through the whole timeframe under analysis (Figure 4).

Having compared the differences of the agricultural products exports of six countries under research to the EU visualised in the figure given above, let’s analyse their peculiarities to capture the common and distinctive features of the subjects under research. As for the Ukrainian agro – exports to the EU, we see, that there were three decreases in their amounts, namely in the years 2013, 2016 and 2020. During the rest



Source: author's elaboration on the basis of the data from Eurostat (2022(c))

Figure 4: Differences of the Agricultural Products Exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU, mil EUR (to be continued).



Source: author's elaboration on the basis of the data from Eurostat (2022(c))

Figure 4: Differences of the Agricultural Products Exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU, mil EUR (continuation).

of the years the positive changes of the said exports amounts were observed. The mentioned decrease in 2013 was probably caused by the turbulences in the political life of Ukraine. The one in 2016 occurred because of the inadaptability of the Ukrainian laws and rules to the EU ones necessary to trade in accordance with the AA/DCFTA provisions. The said decrease in 2020 has become the consequence of the COVID-19 pandemic impact. In addition, the biggest decrease of the mentioned exports was in 2020, while the biggest increase could be observed in the last year under research, and that, in turn could be considered rather contradictory, taking into account the horrible events taking place in the country. Thus, the difficulties imposed by Russia on the Ukrainian agro exports made Ukraine search for different exports routes, many of which flew through the EU member states, having a common border with the country. As the exports become the very exports while crossing a country's border, the mentioned explanation of such a big exports increase seems to be quite logical. The changes pattern of the Brazilian agro – exports to the EU varies from that of the Ukrainian one, having negative changes in the said exports amount in 2013, 2014, 2016 and 2018 – 2020. During the rest of the years, that is 2015, 2017, 2021 and 2022, the positive changes were observed.

The biggest increase of the Brazilian agro – exports to the EU was in 2022 while the biggest decrease – in 2016. As for the Canadian agro – exports to the EU, it could be divided into three clear periods, that is the first period, the upward one, is from 2012 till 2014 included, the second, the downward one, - from 2015 till 2017 included and the third, another upward one, is from the year 2018 till the end of the timeframe under analysis. The biggest increase of the agro – exports from Canada to the EU can be observed in 2014 while the biggest decrease – in 2016. The agricultural exports of China to the EU experienced decreases of their amounts in 2013, 2014 and 2020, the biggest of which was in 2020. During the rest of the years the said exports increased, mostly in 2022. The dynamics of the agricultural exports of the United Kingdom to the EU reflects the changes in the political relations between the subjects – the agro – exports dynamics is upward from the beginning of the timeframe under analysis till the year 2019 included and experienced the first big decrease in 2020, the year of Brexit, followed by even bigger decrease in 2021. Though, the biggest increase of the mentioned exports can be observed in 2022 while the biggest decrease – in the year 2021. Another country having experienced the decrease of the agro – exports amount

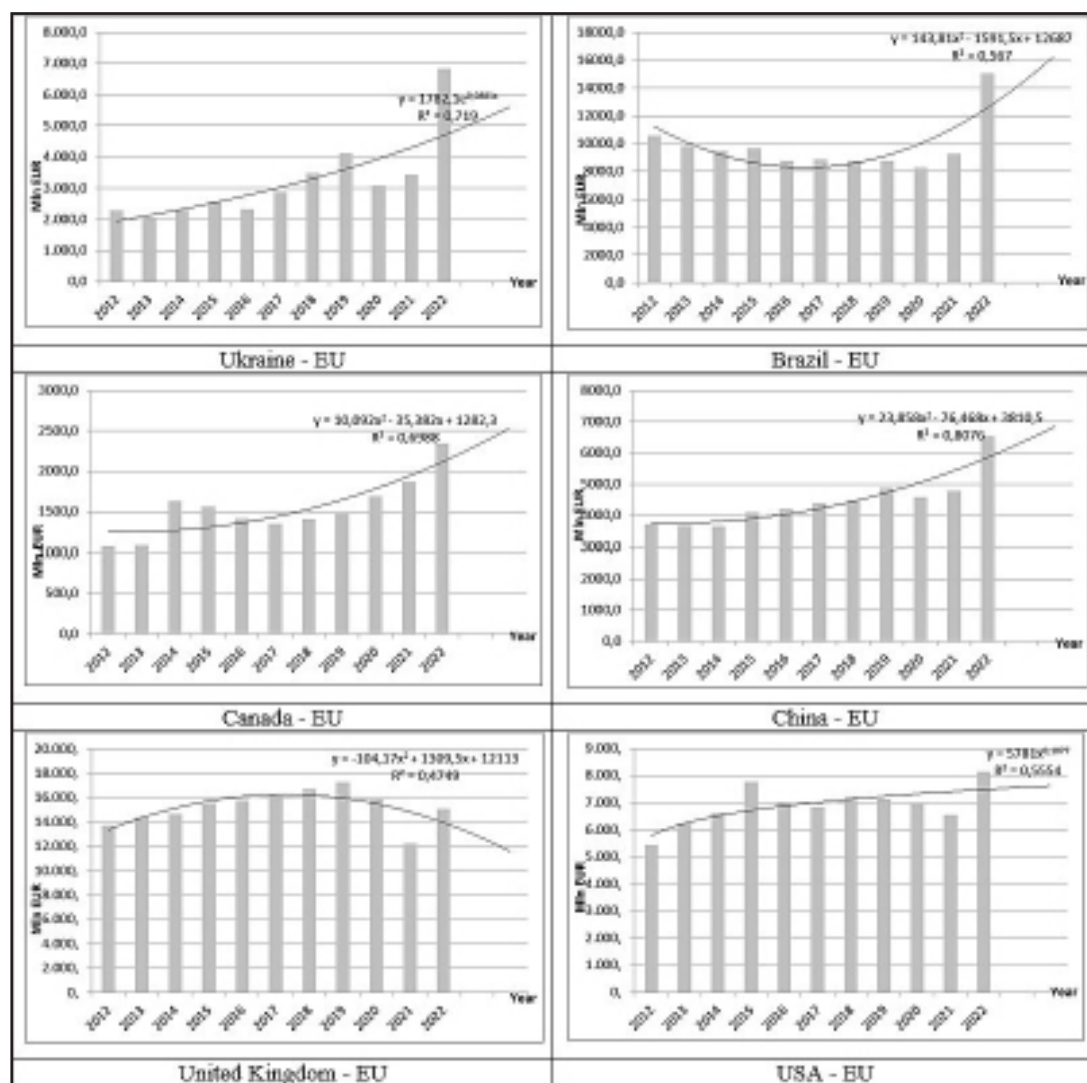


in both 2020 and 2021 is the USA. But, unlike the UK, these were not the only years with the negative change of the mentioned exports. In addition, in the years 2016, 2017 and 2019 the amount for the agro – exports of the USA to the EU also decreased. The rest of the years experienced the increase of the said exports. The biggest increase of the agricultural products exports of the USA to the EU can be observed in 2022 while the biggest decrease – in 2016.

Having compared the changes dynamics for the agricultural products exports of the subjects analysed to the EU, let's build the general trend lines for each data under research taking two following periods, in this case years, for the projection making (Figure 5).

Before analysing the data presented in the Figure 5, it should be stated, that the trend lines

for the data under research were built using the appropriate functions, having chosen from the exponential, linear, logarithmic, polynomial and power ones. The criterion for the choice of the right function was the  $R^2$  coefficient values. Firstly, let's look at the dynamics of the Ukrainian agricultural exports to the EU. It looks rather changeable but the general trend line is upward both during the timeframe under analysis and two following periods taken for the projection making, though, according to the projections for the following two years the said exports amount is supposed to be smaller than that of the last analysed year. The trend line for the data was built using the exponential function. The dynamics of the agricultural products exports of Brazil to the EU looks differently from that of Ukraine – it's not that changeable. In addition, the trend line for the data was built using a different



Source: author's elaboration on the basis of the data from Eurostat (2022(c))

Figure 5: Agricultural Products Exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU, mil EUR

from the previous function, that is with the help of the polynomial one. Though the trend line is upward starting approximately from the year 2019 and continues to be of the kind either till the end of the timeframe under analysis or during two following periods taken for the projection, in the first year following the last analysed one the agro – exports amount of Brazil to the EU is supposed to decrease, increasing again in the second one. The dynamics of the Canadian agro – exports to the EU has a different outlook from the previous two ones. The trend line for the said data was also built with the use of the polynomial function. The trend line of the agro – exports of Canada to the EU is upward through the whole timeframe under analysis and two following periods. But there is still a similarity between the trend lines of the Brazilian and Canadian agro – exports – both trend lines are upward at the end of the timeframe under analysis and two following years, but, comparing to the real data of the last analysed year, the projection for the first projected year is the decrease of the said exports with the following increase during the second projected year. The trend line of the agricultural products exports of China to the EU was also built with the help of the polynomial function just like in the case with the Brazilian and Canadian exports. The trend line is upward during the whole timeframe under analysis and during two following years taken for projection. Comparing the trend line with the real data of the last analysed year,

the projection for two following years looks similar to that of the previous analysed subject. We see a completely different picture when looking at the UK agro – exports to the EU dynamics – it is upward till the year 2017, starting to decline afterwards till the end of the timeframe under analysis, continuing its decline during two more years taken for the projection. The trend line was built using the polynomial function. And last but not the least, the agricultural products exports of the USA to the EU, the trend line of which was built using the power function. The said trend line is slightly upward, though indicating the possible decrease of the last analysed subject agro – exports to the EU during two following years taken for the projection making. It should also be added here, that the trend lines for the analysed subjects through the researched time frame as well as for two following years taken for the projection making, were built *ceteris paribus*.

Having conducted a profound analysis of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the United States to the EU, let's assess whether Ukraine is correlated with each/some/all the subjects under research in terms of their agro exports amounts and whether the said subjects are correlated between each other, and, if they do, how strong the correlation is. In order to do that, the Pearson correlation coefficients (under the  $H_0$  of Rho equals zero) as well as their corresponding p-values were calculated and presented in Table 2.

	Agricultural Products Exports of Ukraine to the EU, mln EUR	Agricultural Products Exports of Brazil to the EU, mln EUR	Agricultural Products Exports from Canada to the EU, mln EUR	Agricultural Products Exports of China to the EU, mln EUR	Agricultural Products Exports of the United Kingdom to the EU, mln EUR	Agricultural Products Exports of the USA to the EU, mln EUR
Agricultural Products Exports of Ukraine to the EU, mln EUR	1	0.7413 <i>p=0.009034</i>	0.8007 <i>p=0.003065</i>	0.9744 <i>p&lt;0.00001</i>	0.1556 <i>p=0.647779</i>	0.6592 <i>p=0.027363</i>
Agricultural Products Exports of Brazil to the EU, mln EUR	0.7413 <i>p=0.009034</i>	1	0.5882 <i>p=0.05699</i>	0.6691 <i>p=0.024354</i>	-0.2274 <i>p=0.502063</i>	0.3649 <i>p=0.26985</i>
Agricultural Products Exports from Canada to the EU, mln EUR	0.8007 <i>p=0.003065</i>	0.5882 <i>p=0.05699</i>	1	0.8337 <i>p=0.001428</i>	-0.1068 <i>p=0.756418</i>	0.7 <i>p=0.016471</i>
Agricultural Products Exports of China to the EU, mln EUR	0.9744 <i>p&lt;0.00001</i>	0.6691 <i>p=0.024354</i>	0.8337 <i>p=0.001428</i>	1	0.1434 <i>p=0.674022</i>	0.6939 <i>p=0.017856</i>
Agricultural Products Exports of the United Kingdom to the EU, mln EUR	0.1556 <i>p=0.647779</i>	-0.2274 <i>p=0.502063</i>	-0.1068 <i>p=0.756418</i>	0.1434 <i>p=0.674022</i>	1	0.4794 <i>p=0.135679</i>
Agricultural Products Exports of the USA to the EU, mln EUR	0.6592 <i>p=0.027363</i>	0.3649 <i>p=0.26985</i>	0.7 <i>p=0.016471</i>	0.4816 <i>p=0.1587</i>	0.4794 <i>p=0.135679</i>	1

Source: author's calculations with the help of Social Science Statistics (n.d.(a)) on the basis of the data from Eurostat (2022(c)).

Table 2: Pearson correlation coefficients of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU.

First of all, let's analyse the values of the Pearson correlation coefficients presented in Table 2.

The Ukrainian agro-exports to the EU has positive close to perfect correlation with the Chinese, positive strong correlation with the Brazilian, Canadian and the US exports as well as positive weak correlation with the UK ones. The Brazilian agro – exports to the EU have positive strong correlation with the Ukrainian and Chinese ones, positive moderate correlation with the Canadian ones, positive weak correlation with the US ones and negative weak correlation with the UK exports. The Canadian agro – exports to the EU have strong positive correlation with the Ukrainian, Chinese and the US ones, positive moderate correlation with the Brazilian and negative weak correlation with the UK agro exports. The Chinese agro -exports to the EU have, besides those mentioned above, positive weak correlation with the UK and positive strong correlation with the US agro exports. The UK agro-exports to the EU have, besides those mentioned above, positive moderate correlation with the US ones. The results presented above are only a half way to the conclusions making. The next step of our research is to assess whether the given results are statistically significant. With the 95% of confidence intervals, that is with  $\alpha = 0.05$ , let's analyse which corresponding p-values indicate the obtained results to be statistical significant and which - not. The close to perfect

positive correlation between the Ukrainian and Chinese, the strong positive correlation between the Ukrainian and the Brazilian, Canadian and the US agricultural products exports to the EU, the strong positive correlation between the Brazilian and the Chinese agro exports, the strong positive correlation between the Canadian with the Chinese and the US agro exports as well as the positive strong correlation between the Chinese and the US agro exports are to be considered statistically significant and allow us reject the H0. The rest of the corresponding p-values indicate the obtained results not to be statistically significant and don't allow us reject the H0.

To make the research results more credible and to double check the presence/absence of the correlation between the subjects under analysis, the Spearman correlation coefficients and their corresponding p-values were calculated and presented in Table 3. There was another motivation to conduct the Spearman correlation test, that is – the Pearson correlation test needs the data to be normally distributed. Having conducted the normality testing, none of the data sets under research appeared to be perfectly normally distributed, though the deviations from the normality were not that big in some cases. So, in order to be perfectly sure in the research results, the Spearman correlation coefficients (under the H0 of Rho equals zero)

	Agricultural Products Exports of Ukraine to the EU, mln EUR	Agricultural Products Exports of Brazil to the EU, mln EUR	Agricultural Products Exports from Canada to the EU, mln EUR	Agricultural Products Exports of China to the EU, mln EUR	Agricultural Products Exports of the United Kingdom to the EU, mln EUR	Agricultural Products Exports of the USA to the EU, mln EUR
Agricultural Products Exports of Ukraine to the EU, mln EUR	1	-0.23636 $p=0.48409$	0.59091 $p=0.05558$	0.93636 $p=2E-05$	0.49091 $p=0.1252$	0.69091 $p=0.01857$
Agricultural Products Exports of Brazil to the EU, mln EUR	-0.23636 $p=0.48409$	1	-0.06364 $p=0.85254$	-0.25455 $p=0.45004$	-0.65455 $p=0.02886$	-0.14546 $p=0.66958$
Agricultural Products Exports from Canada to the EU, mln EUR	0.59091 $p=0.05558$	-0.0636 $p=0.85254$	1	0.55454 $p=0.07665$	-0.08182 $p=0.81099$	0.45454 $p=0.16015$
Agricultural Products Exports of China to the EU, mln EUR	0.93636 $p=2E-05$	-0.25455 $p=0.45004$	0.55454 $p=0.07665$	1	0.37273 $p=0.25893$	0.53636 $p=0.08895$
Agricultural Products Exports of the United Kingdom to the EU, mln EUR	0.49091 $p=0.1252$	-0.65455 $p=0.02886$	-0.08182 $p=0.81099$	0.37273 $p=0.25893$	1	0.6 $p=0.051$
Agricultural Products Exports of the USA to the EU, mln EUR	0.69091 $p=0.01857$	-0.14546 $p=0.66958$	0.45454 $p=0.16015$	0.53636 $p=0.08895$	0.6 $p=0.051$	1

Source: author's calculations with the help of Social Science Statistics (n.d.(a)) on the basis of the data from Eurostat (2022(c)).

Table 3: Spearman correlation coefficients of the agricultural products exports of Ukraine, Brazil, Canada, China, the United Kingdom and the USA to the EU.

and the p-values corresponding to them have been decided to be calculated.

Just like with the Pearson correlation coefficients, let's, first of all, take a look at the values of the Spearman correlation coefficients, presented in the table given above. Judging by the Spearman correlation coefficients values, the Ukrainian agricultural products exports to the EU have negative weak correlation with the Brazilian ones, positive moderate correlation with the Canadian and the UK ones, positive close to perfect correlation with the Chinese ones, positive strong correlation with the US agro exports. The Brazilian agro – exports to the EU have negative weak correlation with the Canadian, Chinese and the US ones and negative strong correlation with the UK agro exports. The Canadian agricultural products exports to the EU have positive moderate correlation with the Chinese and the US ones and negative weak correlation with the UK agro exports. The agro-exports of China to the EU have positive weak correlation with the UK and positive moderate correlation with the US agro exports. The agro-exports of the UK to the EU have positive moderate correlation with the US ones. The countries mentioned once in the Spearman correlation coefficients explanation were not repeated again. With the 95% of confidence intervals, that is with  $\alpha = 0.05$ , let's analyse what corresponding p-values indicate the obtained results to be statistical significant and what will allow us reject the  $H_0$ . Judging by the corresponding p-values, positive strong close to perfect correlation of the Ukrainian agro-exports to the EU with the Chinese ones, positive strong correlation of the Ukrainian agro exports to the US ones, negative strong correlation of the Brazilian agro – exports to the EU with the UK ones are to be considered statistically significant and allow us reject the  $H_0$ . The rest of the corresponding p-values don't allow us reject the  $H_0$ .

The right for food security is an essential need of every human being, no matter who or what they are and where they live. On the one hand, the government of every country must secure sufficient amount of food for the population of its country as it is one of its duties, but, on the other hand, having its population fed and satisfied is of the best interests for every government, though not everyone understands this realness as the turbulences of nowadays show. In order to supply one's population with the sufficient amount of food, countries' officials search for the new trade partners, sign new contracts,

establish new logistic routes, make new unions. Neither the economic development level nor the territory greatness plays any role in this case. The only thing that matters is what agricultural products, how much and how quickly the new partner can provide. In this manner, the global agricultural products market is being reorganised due to the appearing changes/needs/challenges of nowadays. The research presented above is only the first step in the attempt to clarify the way the global agro – market functions. The matter under research is extremely interesting and topical nowadays due to the turbulences in all the spheres of the human activity. The correlation between the agro – market subjects analysed in the paper doesn't imply the causation, which, in turn, could be the possible direction of the research expansion. Another matter interesting to be researched is the interaction of the countries unions from different continents as the subjects of the global agricultural products market. The correlation of the countries of one continent as the agro – market subjects is the following issue interesting to be discussed. And these are not the only directions of the presented research expansion as the matter of the agro – products trade and their subjects' interaction is vitally important for human survival and life quality. Despite the vital importance of the matter under research, there are certain limitations that could harden the research flow. These are, added to the existing ones mentioned above, the differences in the statistical data gathering, assessment, storage, processing and presentation, the availability of the statistical data on the matter under research, the availability of the statistical software to analyse the researched data, the readiness of the scientific journals to publish the research results without paying attention on the political issues between the analysed subjects, as well as the force majeure circumstances, that can appear unexpectedly and can turn the fixed matter, according to which things are functioning, upside down, etc.

## **Conclusion**

The challenges we all are facing nowadays, being it climate changes, COVID-19 pandemic, turbulences within or between countries, all of them threaten our lives, and not only the way of life we are used to, but the very life itself. And no life is possible without food being it a single human being or the whole humanity. That's why, every single human being, the governments of all the countries, the decision makers of different levels consider food security to be vitally important and needed



to pay constant attention at. Due to the turbulences we have experienced and are still experiencing, we think whether we have enough food not only for today, but for the nearest future, making some food supplies not only on the local, but global level as well. Therefore, the subjects supplying agricultural production and ready-made food products are becoming more and more important and influential. Among the biggest global goods exporters, we see either the biggest territorially or the most highly developed countries, like China, the USA, Germany, the Netherlands, Japan and others. But, when we talk about the countries, which are the biggest exporters of the agricultural products, the list looks a little bit differently, including a mix of either big or small and highly developed and not that developed countries, like the EU (as a country union), the Russian Federation, Australia, Ukraine, the United States, Canada, Argentina, Kazakhstan, Turkey, etc. On the one hand, a big territory means more land for the agricultural production and the high level of the country's economic development means the availability of better mechanisms and technologies to reach better results, that is higher amount of the end products. But, as far as we can see, either relatively small or not that developed countries can also take leading places among the most influential global agro – exporters, becoming therefore noticeable players on the global market.

Ukraine, as an example of such a relatively small and not considered a highly developed country, was taken by the author to assess whether such a country's agricultural products exports to the EU correlate with the ones of the biggest and the most influential global agro – exporters, that is with Brazil, Canada, China, the UK and the USA, and if they do, how strong the correlation is. All the said countries take prominent places among the producers and exporters of certain agricultural products, that is Ukraine – of sunflower seeds and oil, rapeseed, wheat, barley, maize, and soybeans; Brazil – of soybeans, corn, wheat, poultry; Canada – of canola, cattle and calves, beef and veal, vegetables and poultry; China – of rice, wheat, potatoes, tomato, sorghum, peanuts, tea, millet, barley, cotton, oilseed, corn and soybeans; the United Kingdom – of wheat, barley, vegetables, horticultural and livestock products; the USA – of meat, soybean, corn, wheat, fruits, vegetables, and nuts.

The comparative analysis of the agricultural products exports dynamics of the subjects under research point to the fact, that the least amount

of the said exports during the presented timeframe can be observed by Canada and the biggest one – by the United Kingdom. The countries mentioned in the previous sentence take also the opposite places in terms of their exports dynamics flatness – the agricultural products exports of Canada to the EU dynamics is the flattest while the UK's one – the most spiky. Ukraine takes the fifth place among the six given countries as for the agro-exports amount and the third place in terms of the data dispersion. An observation worth taking a special attention at is the change of the agro-exports to the EU amount in 2022 – all the analysed countries noted the positive changes in the agro exports to the EU amount, moreover, in the cases of five out of six, except Canada, those changes were the biggest during the analysed timeframe. In addition, if the minimum values of the agricultural products exports to the EU were experienced by the researched countries in different years, the maximum values were seen in the same year by all the analysed subjects with the only exception of the UK. The increased inflation made its influence on the data mentioned previously, but the turbulences between two European countries made the fixed exports routes be changed in order to ensure food security for the African and Eastern countries, making the agricultural products exports from Ukraine flow through the EU member – states mostly, that, in turn, gave the results presented above. That means, that the repeated blockage of the Grain Deal implementation, resulting in the dozens of the Ukrainian ships transporting agro production, mostly grain, to the African and Asian countries, being blocked in the Black Sea, made Ukraine and its allies search for the new routes and means to export the Ukrainian agricultural production from Ukraine to those in need. As Ukraine borders on, among the others, Hungary, Poland, Slovakia and Romania, which are the EU member – states, most of the agricultural production exports, which could not be transported through the blocked water ways, started to be transported through the territories of the mentioned countries. Since the fact of export is being stated at the time of the goods crossing the border, the often suspensions of the Grain Deal implementation and the urge to export the Ukrainian agricultural production through the territories of the EU member – states impacted the increase of the agro exports being under research.

The trend lines for the subjects under analysis were built using the appropriate functions, chosen from the exponential, linear, logarithmic,

polynomial and power ones, judging by their  $R^2$  coefficient values. The said trend lines are upward in all the analysed cases, except the UK – the EU agro exports, though the projections for the agricultural products exports of the analysed subjects were made *ceteris paribus*. The results of the Pearson correlation coefficients calculations of the agricultural products exports of six analysed countries to the EU with their corresponding p-values point to the close to perfect positive correlation between the Ukrainian and Chinese, the strong positive correlation between the Ukrainian and the Brazilian, Canadian and the US agricultural products exports to the EU, the strong positive correlation between the Brazilian and the Chinese agro exports, the strong positive correlation between the Canadian with the Chinese and the US agro-exports being considered statistically significant, allowing us to reject the  $H_0$ . Having calculated and analysed the Spearman correlation coefficients of the agricultural products exports of six mentioned countries to the EU with their corresponding p-values, it can be stated, that positive strong close to perfect correlation of the Ukrainian agro-exports to the EU with the Chinese ones, positive strong correlation of the Ukrainian agro exports to the US ones, negative strong correlation of the Brazilian agro – exports to the EU with the UK ones are to be considered statistically significant, allowing us reject the  $H_0$ .

So, having conducted the research presented in the article, the scientific hypothesis, that even a territorially small country can be considered a prominent player on the global agricultural market, should be taken into account and is correlated with the other big market players, is considered to be proven. Despite the fact, that Ukraine is not considered to be among the territorially biggest countries in the world, it takes leading places among the producers and exporters of such agricultural products as sunflower seeds and oil, rapeseed, wheat, barley, maize, and soybeans. The agricultural products exports of Ukraine to the EU have positive close to perfect correlation with the Chinese ones and positive strong correlation with the US ones. As a result, any turbulences even in the smallest country, that can threaten its agricultural production and exports, should be regulated and diminished not to threaten the food security of either the said single country or many other bigger countries and, as a consequence, the global food security. Having filled in the knowledge gap stated above, the presented research and its results are of great interest and use for public administration officials of all the levels, companies' employees engaged into international trade in general and of agricultural products trade in particular, decision makers, academic community representatives as well as beginners and experienced statisticians and data analytics.

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