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The Russia-Ukraine invasion toward increasing food security threat for population: An empirical study using T-GARCH model

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Abstract. *The aim of the present paper is testing the impact of the Ukraine-Russia invasion on food security. To achieve our investigation a daily data was used for the period of 20th September 2020 to 20th September 2022 using most vulnerable commodities to this geopolitics risks. Primary findings under T-GARCH model concluded that the variables highly affect by the bad news including both of the Covid-19 pandemic following by the Ukraine war in the edge of 2022. This finding confirmed what was stated in the global reports about the food insecurity risk which has become a real threat for the population.*

Keywords: food security, Ukraine war, commodities, hunger risk, T-GARCH model.

JEL Classification: C02, C32, E31, F51.

1. Introduction

Word bank food security updates demonstrate that global domestic food price inflation is still high. Nearly all low- and middle-income countries have high inflation, according to data from May to August 2022. 93.3 percent of low-income nations, 90.9 percent of lower-middle-income nations, and 93.3 percent of upper-middle-income nations have experienced inflation levels above 5 percent, with many experiencing double-digit inflation. With about 85.7 percent of high-income nations experiencing high food price inflation, the proportion of nations with high inflation has also sharply increased (Blanchard and Pisani, 2022, p. 3).

Although the Russia-Ukraine invasion may have had a significant impact beyond the immediate area, particularly on food prices (Alam et al., 2022, p. 2), The global statistics, food insecurity had been on the rise even before the Ukraine War. Since there has been an increase in hunger for many years, even before the current crisis and the Covid-19. In 2020, there were already 800 million hungry people, and that number was growing by 100 million in compare with the last year. This is due to the Covid-19 pandemic as well as the enduring causes of food insecurity like war, severe weather, pests, and diseases. Acute huge food insecurity affected 388 million people across 42 countries, which is more than 5 percent higher than in 2020, putting people's lives at immediate risk.

The goods that are most negatively impacted by the conflict are primarily wheat, to a lesser extent maize, vegetable oils, and most significantly fertilizers. The main product affected by the invasion is wheat among these. The largest exporter of wheat is Russia, which will account for 18% of global exports in 2021 and nearly 20% of global exports overall (Ahmad et al., 2022, p. 3). Ukraine will contribute another 10%. Nowadays, Russia and Ukraine are no longer the largest producers of wheat, but they are the biggest exporters, with about 35% of the world's population depend on wheat as their main dietary staple. Which resulted in a significant shock regarding the spike in wheat prices on the global markets, rising by more than 50% and nearly 80% from a year earlier. Following the invasion, maize prices rose slightly as well, by about 25 to 30 percent above February levels and by about 37 percent on an annual basis, making those two commodities truly more expensive (van Meijl et al., 2022, p. 14). Other goods like rice are unaffected by the invasion, and their costs are still lower than those of wheat. The expert claims that if exports from Russia and Ukraine are still prohibited, stock levels in the countries that used to import from those countries will suffer, and forcing them to make expensive adjustments.

This conflict also has a big and important effect on fertilizer prices because it might actually result in production problems for all crops the following season if yields plummet because farmers can't get or afford enough fertilizer, which could cause yields to fall. Russia exports 20% of the world's fertilizers, and because of the high cost of urea and oil, fertilizer prices were already higher before the war.

The importing nations with a high proportion of wheat imports from Ukraine and Russia are at the greatest immediate risk of invasion (Kuhla et al., 2022, p. 5), particularly those who are still awaiting shipments for the second half of the year, Egypt, for example, is still waiting for 6.6 million tons, Turkey, Bangladesh, Iran, and other Middle Eastern nations

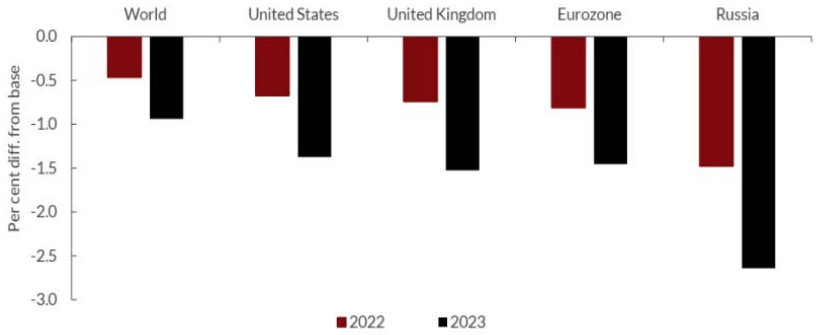
are also major wheat importers, as are the Mena Region and North of Africa, which depend on the Russia-Ukraine supply chain. Based on what we've said so far, we can say that the Russian-Ukrainian war could have serious consequences for weaker nations in a number of global regions, especially, Middle East and North African countries. These nations will always be the poorest and experience the most suffering if humanitarian and development decisions are not scaled up (Tárik, 2022, p. 7).

Based on all what we highlighted above about the global food crisis – that is caused by numerous reasons such as Covid-19 and the Ukraine war – we will examine the behavior of the most commodities vulnerable to the global fluctuations in international commodities markets. To achieve our objective, we will analyze some previous literatures includes updated reports from international organizations and different research papers that investigate the same topic. The rest of our paper will organize as follow: section two presents some statistics about food prices in globe, third section includes the literature reviews, the methods will be presented in the fourth section, the five section demonstrate the discussion and finally, we have the main conclusion.

Ukraine-Russia invasion impact on global economic indicators

According to the global statistical given by the international organizations and databases, the war in Ukraine caused a significant effect on the economic indicators in the world wide, since Russia and Ukraine are a major food supplier for many regions and countries. National Institute of Economic and Social Research presented a short statistic about the global level of GDP which is reduces by 1% in 2023 because of the Russian military actions this will cost the world 1$ trillion of global GDP (Figure 1).

Figure 1. *The global GDP development*

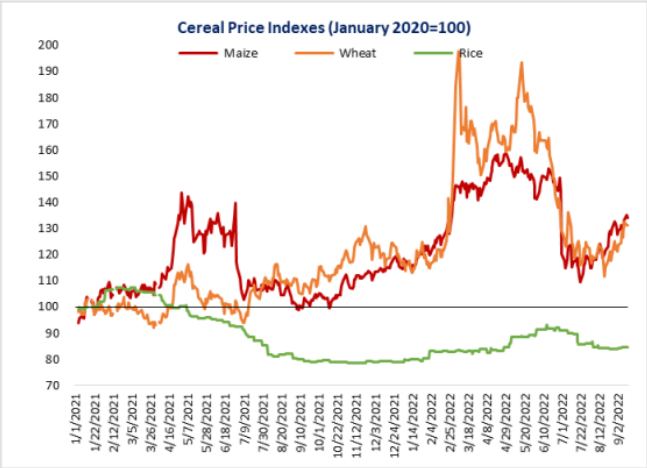


Source: Liadze et al., 2022, p. 1.

Commodities prices in financial markets

The World Bank data prices indicated that the agriculture price index still relatively stable with 1% point higher. Wheat and maize prices showed a significant jump during the invasion period. The maize prices rose in global markets by approximately 12 points following by wheat which increased with 7 points. Wheat and maize prices rose with 17 and 29 percent respectively higher than September 2021, and 31% 34% higher than January 2021 respectively (Figure 2).

Figure 2. *Cereal prices index in global markets*



Source: World Bank commodity prices.

2. Literature review

(Ben Hassen and El Bilali, 2022) examine the effect of the Russia-Ukraine invasion on the food security in the world. The investigation tried to show the negative effect of the war which posing a big challenge for some nations around the world particularly, those that depend on food imports. In the same time the authors also put the light on the bad situation before this war where the agriculture markets have affected by the Covid-19 pandemic. The main findings show that the Russia-Ukraine war can jeopardize the Sustainability Developments Goals in the worldwide by increasing the poverty, famine and the health of people. (Glauben et al., 2022) highlighted the dark side of the Russian-Ukraine war on food security by driving up the tensions on the global agricultures markets. They also discussed the instability of commodities markets especially grains and vegetables oils during the Covid-19 pandemic period when the prices have been rose dramatically. This situation affected the dependent countries which import the agriculture products such as MENA region, Middle East, North Africa and different region in the worldwide. (Berkhout et al., 2022) gave us a short analysis about the impact of the Russia-Ukraine invasion on the food security and explaining the consequences of this war in short term. The report talked about many important points which cause a real problem of agriculture commodities consumption in the dependent countries such as the supply problem of raw materials for the export countries, especially the transport supply chains in Ukraine which is no longer available. This current situation put more pressures on prices in the global markets. (Abu Hatab, 2022) explains how the Russia-Ukraine war led to a real social and political crisis. The report focused on the global shock of food supply chains and the negative consequences for the African countries since the food system in Africa is more vulnerable to the instability of food security, particularly when the major players of global food markets are Russia and Ukraine. (Donnellon-May and Teng, 2022) tested the impact of the Russian-Ukraine war on the Middle-east countries and how they are linked with the global food system. (Shams

et al., 2022) analyzed the instability of food and biofuel markets, wherein they referred to the significant role of Russia and Ukraine in the distribution of energy and food especially grains and vegetables oils. (Jagtap et al., 2022) presented the implications of the Russia-Ukraine invasion on the food supply chains in the world. The authors also mentioned the big damage caused by this war that driving up the food prices in global markets, which make the nations reliant on food and grains imports in troubles. (Glauben et al., 2022) put the light on how the Russia-Ukraine war affected adversely the import-dependent countries such as sub-Saharan, MENA region, the Middle East and most of the nations that heavily rely on Russia and Ukraine food exports. (Benton et al., 2022) tried to explain the time effect of the Russia's invasion of Ukraine. According to authors the war's implications will be long and have a lasting consequences on societies in global. (Lang and McKee, 2022) focused on the difficulties that faced Ukraine to export food since the main port is blocked because of the war. In the same line the authors highlighted how it is difficult for the other countries to deal with shortfall on the food supply. (Chepeliev, 2022) showed the importance of the Black Sea Region on the food supply chains. After the Russia-Ukraine invasion this region became blocked which make a heavily pressure on food prices (Sokolovska et al., 2022). This article presented the negative impact of the Russian military actions against Ukraine, this situation creates an emergence of new threat in Europe. According to the authors Russian aggression has exacerbated the food security problem in the world.

(Baranowski, 2022) discussed the Russia-Ukraine invasion impact on the energy and food system, this study based on a survey for 10 European countries which confirmed that most of the respondents show them desire to end the war as soon as possible. (Uwishema et al., 2022) focused on the impact of the Ukraine war and the Covid-19 pandemic on the healthcare system in globe and especially for Ukrainian people.

(Mengoub et al., 2022) investigate the impact of Russian military actions on food security in Morocco especially for cereals imports. The authors concludes that the government have to deal with this crisis by encourage the agri-food investments, in order to achieve the stability. (Tokarchuk et al., 2022) showed the importance of agriculture corps on the biofuels productions and how the conflict between Russian and Ukraine make it worse especially for Ukraine. European Commission (2022) highlighted the major consequences of the Ukrainian war for increasing the food security crisis in glob.

Research gap

In the literature review section, we distinguished the latest research papers and most updated reports about food security crisis, the main results that they found has been also showed. We noticed that the common aim of these previous studies is highlighting the impact of the Ukraine war on food security in global, by limiting the analysis area between the period when the war starts last February 2022, till now. Furthermore, the authors didn't mention the several reasons that make food security crisis gone up. Based on these limits shown in the literature review, we tried to close the gap by taking in consideration the main reasons of food security crisis with an extension of the selected period of our study that is arranged between September 2020 to September 2022, including the complications of Covid-19 pandemic period following by the Russia military actions damages.

Research hypotheses

H_1: The Russian Ukraine invasion has a negative effect on the commodities prices.

H_2: The augmentation of food security crisis back to several reasons not only to the Ukraine war.

3. Data and methodology

The current paper makes use of some econometrics methods to carry out the empirical analysis. We used the following methodology for our investigation:

Firstly, we will represent descriptive statistics and the heteroskedasticity test for all the variables in case of the time series data ARCH test. For testing the effect of the recent shocks, we will use the GJR-GARCH model. Our data downloaded from Thomson Reuter database by specifying the most commodities vulnerable to the last events, Covid-19 and the Russia-Ukraine invasion. The selected sample cover the period of 20 September 2020 to 20 September 2022 with daily data.

3.1. Econometric model

News, events incidents, etc. have a strong and powerful impact on the decision making of financial investors. Therefore, have asymmetric effect on financial markets across the globe.

A standard ARCH and GARCH model treat bad news (negative shock u_{t-1} p 0) and good news (positive shock u_{t-1} f 0) symmetrically. The impact on asset volatility h_t is the same. In ARCH/GARCH models a big positive/negative shock will have exactly the same magnitude in the volatility of the series. However, the impact of good and bad news on financial assets or on markets may be asymmetric, since the financial market became more vulnerable the econometricians have created ways to capture the effect of the instability on financial assets using the Threshold GARCH (T-GARCH) model introduced by Zakoian (1990) and Glosten et al. (1993). The main purpose of this model is detecting the asymmetries terms of negative/positive shocks. The usage of T-GARCH model is simple, it needs to add into variance equation a multiplicative dummy variable to check whether there is statistically significant difference between positive and negative shocks.

The conditional variance for T-GARCH model is given as follow (Francq and Zakoian, 2019, p. 10):

$$h_t = \varphi + \theta_1 h_{t-1} + b_1 u_{t-1}^2 + y_1 u_{t-1}^2 D_{t-1}, \qquad (01)$$

where Dt represents the dummy variable, it takes 1 (bad news) for u_{t-1} p 0 and 0 otherwise, it means bad news and good news have a different effect. The good news getting by b1 and the bad news getting by $b_1 + \gamma_1$. Where γ is the asymmetric term. When this term is positive and significant that means the negative shocks has a large effect on h_t than the positive shocks.

The T-GARCH model can be more specifying as follow:

$$h_t = \varphi + \sum_{k=1}^{p} \theta_k h_{t-k} + \sum_{i=1}^{q} (b_i u_{t-}^2 + \gamma_i D_{t-i}) u_{t-i}^2 \quad (02)$$

Table 1. *Data description*

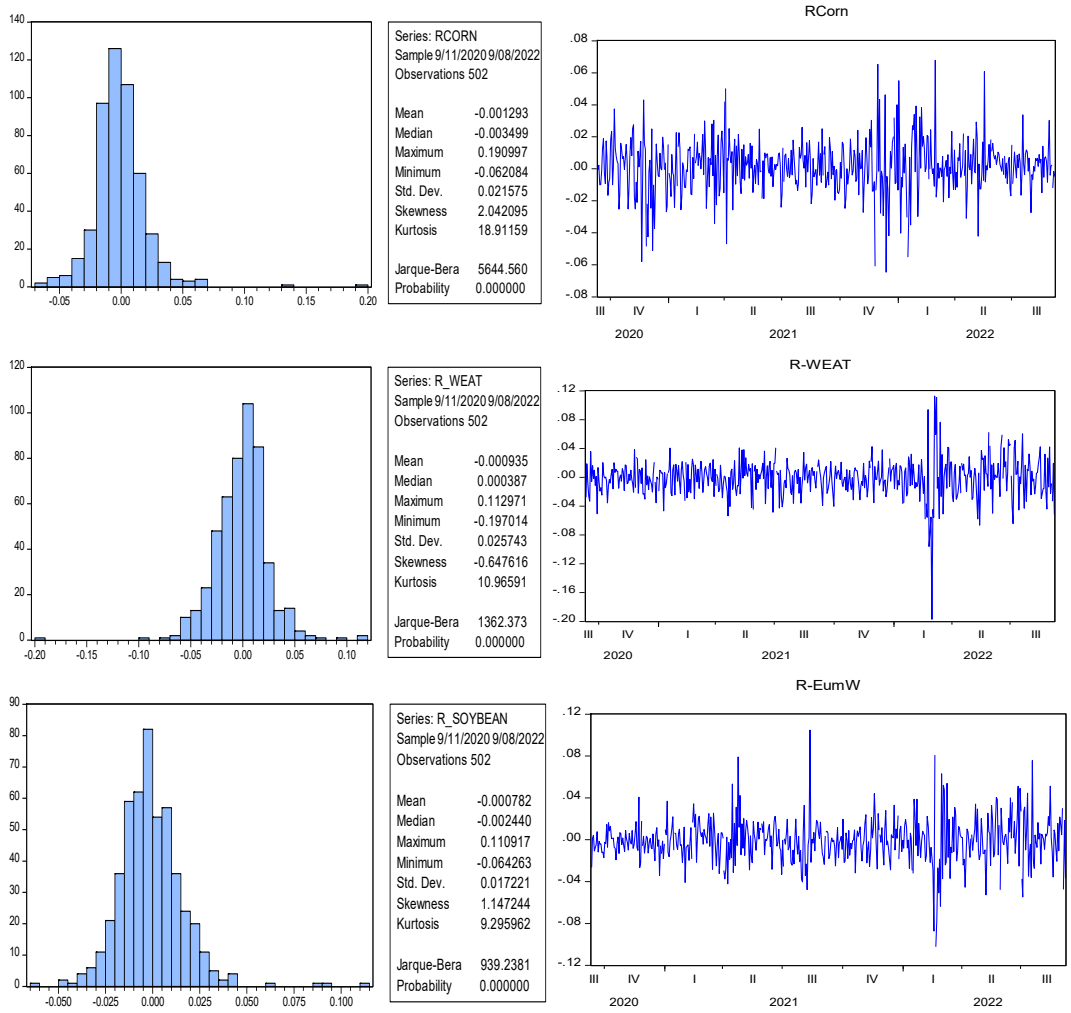
Commodities	Abbreviation
Wheat	R-Wheat
Paris Euronext-Wheat milling	R-EuMW
Corn	R-Corn
Soybean	R-Soybean

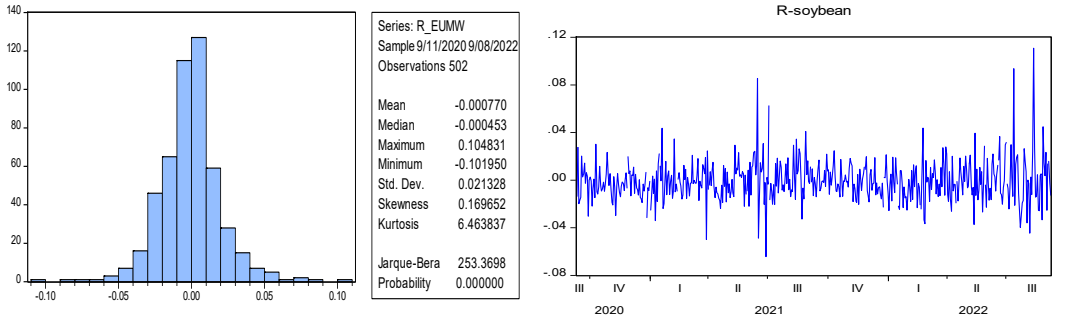
Source: Author.

3.2. Results

Our results will illustrate it bellow:

Figure 3. *Presentation of histogram and graphs for wheat, corn and soybean oil returns*





Source: Author.

The figures above represent the selected commodities returns graphs and the histogram tables. We can see that there are a noticeable movement for the returns during the selected period especially during the Ukraine war period. The wheat returns increased in the first quarter 2022 by 12 point because of the military actions of Russia, then the sharp declined in the second and the third quarter in the same year. The Euro wheat milling jumped from 7 to 6 points in the second quarter followed by soybean with an augmentation of approximately 12 points in the third quarter of 2022.

In order to know the characteristics of our variables the descriptive statistics was carried out.

Table 2. *Descriptive statistics*

	R_EUMW	R_SOYBEAN	R_WEAT	RCORN
Mean	-0.0007	-0.0007	-0.0009	-0.0012
Median	-0.0004	-0.0024	0.0003	-0.0034
Std. Dev.	0.0213	0.0172	0.0257	0.0259
Skewness	0.1696	1.1472	-0.6476	2.0420
Kurtosis	6.4638	9.2959	10.965	18.911
Jarque-Bera	253.3698	939.2381	1362.373	5644.560
Probability	0.000000	0.000000	0.000000	0.000000
Observations	502	502	502	502

Source: Author.

The table above shows the descriptive statistics of the variables according to the standard deviation the Corn returns shows a large volatility than the other variables with a deviation of 2.59% from his mean, followed by the Wheat returns 2.57%, Euro wheat for milling 2.13% and the soybean oil with lower fluctuation reached 1.72% during the selected period. According to Jarque-Bera criteria the variables are normally distributed. Next step is testing the unit root existence for the variables. Next step is testing the Heteroskedasticity test using ARCH LM test.

Table 3. *Heteroskedasticity test*

ARCH Test	Wheat	Euro wheat milling	Corn	Soybean
F-Prob	0.0001	0.0000	0.0000	0.0000
Prob-Chi-Square	0.0001	0.0000	0.0081	0.0073

Source: Author.

The ARCH test was curried out to assess the null hypothesis that the series of residuals (rt) exhibits no conditional Heteroskedasticity. The table above highlighted that Chi-Square probability lower than P-value at 5% of significance, which mean we reject the null

hypothesis and accept the alternative hypothesis that show the existence of the ARCH effect in this series.

After running the ARCH test which assesses the Heteroskedasticity in the selected residual returns series, we will move to run the T-GARCH model in order to test the effect of both of bas and good news on the commodities returns.

Table 4. *The T-GARCH model*

ARCH Test	C	RESID(-1)^2	RESID(-1)^2*(RESID(-1)<0)	Prob	GARCH(-1)	Prob
Wheat	4.07E-05	0.1215	0.0421	0.0451	0.7829	0.0000
Euro-Wheat	2.55E-05	0.0837	0.1626	0.0014	0.7906	0.0000
Corn	9.48E-06	0.1360	0.0554	0.0442	0.8621	0.0000
Soybean	9.82E-06	0.0892	0.0160	0.0376	0.8902	0.0000

Source: Author.

According to variance equation the coefficient of the asymmetric term is positive for all the variables wheat, euro-wheat, corn, soybean 0.042, 0.162, 0.055, 0.016 respectively, and statistically significant at 1% and 5% level indicates that for these commodities returns there are asymmetries in the news. In other word the bad news has a larger effect on the volatility of the commodities returns than good news. The following equation represent the larger effect of bas news

$$b_1 + \lambda \succ b_1 \tag{03}$$

Determine the positive and negative shocks

Wheat

Shock (+): The estimate of time varying volatility is given by:

$$\hat{h}_t = 0.00000407 + 0.782\hat{h}_{t-1} + 0.121\hat{u}_{t-1}^2 \tag{04}$$

Shock (-): The estimate of time varying volatility is given by:

$$\hat{h}_t = 0.00000407 + 0.782\hat{h}_{t-1} + (0.121 + 0.042)\hat{u}_{t-1}^2 \tag{05}$$

Euro wheat milling

Shock (+):

$$\hat{h}_t = 0.00000255 + 0.790\hat{h}_{t-1} + 0.083\hat{u}_{t-1}^2 \tag{06}$$

Shock (-):

$$\hat{h}_t = 0.000000255 + 0.790\hat{h}_{t-1} + (0.083 + 0.162)\hat{u}_{t-1}^2 \tag{07}$$

Corn

Shock (+):

$$\hat{h}_t = 0.000000948 + 0.862\hat{h}_{t-1} + 0.136\hat{u}_{t-1}^2 \tag{08}$$

Shock (-):

$$\hat{h}_t = 0.000000948 + 0.862\hat{h}_{t-1} + (0.136 + 0.055)\hat{u}_{t-1}^2 \tag{09}$$

Soybean oil

Shock (+):

$$\hat{h}_t = 0.000000982 + 0.890\hat{h}_{t-1} + 0.089\hat{u}_{t-1}^2 \quad (10)$$

Shock (-):

$$\hat{h}_t = 0.000000982 + 0.890\hat{h}_{t-1} + (0.089 + 0.016)\hat{u}_{t-1}^2 \quad (11)$$

The difference between bad and good news of the commodities returns is 0.042, 0.162, 0.055 and 0.016 respectively, which is the of asymmetric term λ.

4. Discussion

The Ukraine war pushes the global prices to record high, this the hard reality after the Russian military actions. The conflict between the most large food suppliers in the world put the food security under enormous pressure. Our empirical study aimed to examine the effect of Ukraine war on some commodities prices that are most vulnerable to thus invasion. The outputs of GJR-GARCH model highlighted that all the selected commodities have affected by the bad news and got a negative shock this result confirmed the findings of (Ben Hassen and El Bilali, 2022), which mean Wheat, corn and soybean prices rose significantly in the global markets. According to the experts the war in Ukraine not only the main reason of this sharp augmentation in prices, there are several reasons pushed food prices higher including Covid-19 pandemic that highly affected the supply chains because of the global restrictions, when the lockdown forced people to stay home and increase the consumption level. Food production costs also increased because of the labor turnover in addition to the prevention processes to protect the products from the contamination that led to increase the transportation costs confirmed results (Berkhout et al., 2022). Back to our result the augmentation of food prices especially grains and cereals have been predicted by the analysists since Russia and Ukraine are the largest producers of wheat accounting 30% in global. On the last July Russia and Ukraine signed an agreement to export approximately 20million tons of grains that were blocked in the black sea port. This deal can give the global markets a short breath but the consequences will last for longer, as Ukraine will unable to stay as a major wheat supplier for the dependents countries that will face a large shortage. The short-term exports mean the food prices will be much higher. The energy sector also has a role on this crisis when the western countries banned the Russia imports which led the augmentation of oil and gas prices by 23.8% from the last August to August 2022 and the transportation costs as well.

5. Conclusion

The current paper investigated the impact of the Ukraine war on food security, by selecting the most vulnerable commodities to these fluctuations and instability in global markets. We concluded that the grains and cereals has been affected negatively by this conflict, which push the food crisis to be worse because of the trade restrictions especially in the black sea

region. The updated global report about food security, concluded that the number of people suffering from food crisis will reach up 205.1 million in more than 45 countries in the worldwide. While the global statistics and expectations reported that Ukraine war gave the world a global alert of food insecurity in ways that driving up the prices till the end of 2024.

Research limitation

The findings of this study have to be seen in light of some limitations such as the collection of the data that includes only the most vulnerable commodities and that have more fluctuations, since the econometric model we used (T-GARCH) model one of the models that can run only for the time series with high volatility. Also, the selected period arranged between 20th September 2020 to 20th September 2022, this period covering two main events: Covid-19 pandemic and the Russia-Ukraine conflict that made the food security crisis worse than before.

Future research. The research that has been undertaken for this paper has highlighted a number topics on which future research would be beneficial.

- The impact of the energy sector on rising the food security crisis.
- The global recession caused by the Ukraine war by focus on the global economic indicators (GDP).
- The effect of the geopolitics during the war on the global trading size.

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