Comparative Impact of Covid-19 and the Russia-Ukraine War on Global Staple Food Prices

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Abstract

This study compares the impact of Covid-19 and the Russia-Ukraine war on global staple food prices to know which is more dangerous. The error correction model (ECM) was used to examine the impact of Covid-19 and the Russia-Ukraine war on global wheat, maize, soybean, and rice prices. The study used data from January 1997–June 2023 from various source databases. Covid-19 increased the global wheat, maize, and soybean prices in the long-run but had no impact at all in the short-run. Meanwhile, the Russia-Ukraine war only raised global wheat prices in the short-run but did not affect other global staple food prices. Covid-19 has spurred a bigger increase in global staple food prices than the Russia-Ukraine war. Increases in the short – and long-run global wheat, maize, and soybeans prices have also been attributed to rising global oil prices. The rise in urea fertilizer prices led to a short- and long-run increase in the price of rice globally while simultaneously lowering the price of wheat globally.

Keywords	***DOI***	***JEL code***
Wheat, maize, soybean, rice, food price volatility	*https://doi.org/10.54694/stat.2024.29*	*E31, E64, Q18*

INTRODUCTION

The Covid-19 pandemic has been a serious health threat to the world since late December 2019. It caused 5.32 million deaths around the world at the end of 2021. The pandemic disease significantly affected health, economy, social life, and supply chain activities, including agriculture (Hammad et al., 2023; Paul et al., 2023). According to the International Monetary Fund, the global economy contracted by more than 3% in 2020. More than a billion people have been forced into poverty caused by Covid-19, which estimates that 87% of people in sub-Saharan Africa, Asia, Latin America, and the Caribbean are in poverty (Hammad et al., 2023). Even more significant are the negative effects of the epidemic on the price of staple foods. Previously, there had been a pattern of falling real farm prices as a result of rising agricultural productivity (McCann et al., 2023). Every country is adopting different actions to prevent the spread of Covid-19

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and sustain these economies in the short-run and revamp them in the long-run (Amutabi, 2022). Some of these actions such as limiting human contact by implementing social distancing, staying at home, closing numerous business outlets, and lockdowns (Wallingford et al., 2023). Furthermore, governments all over the world are establishing and putting into effect a variety of tax, economic, and monetary policies to help lessen the negative effects of the pandemic (Amutabi, 2022).

Even though these measures have been successful in halting the spread of the new coronavirus, they have had far-reaching effects on various facets of the economy such as healthcare services, food supply, education, mental health, and quality of life among others (Chang et al., 2022). They have also decreased labour availability and restricted access to inputs, which has disrupted the product supply chain (Cariappa et al., 2022). Food shortages, a decrease in dietary diversity, and a rise in emotional suffering happening everywhere caused by the loss of jobs and inflation (Chang et al., 2022; Manyong et al., 2022). This could affect the ability of vulnerable households to buy enough food and the length of their periods when they are unable to meet their feeding needs is rising (Hammad et al., 2023). Making problems worse, the lockdown raises the possibility of food-related conflicts, food looting, riots, and violence against civilians (Gutiérrez-Romero, 2022).

Unfinished overcoming the Covid-19 pandemic, the world was shaken again by the Russia-Ukraine war in February 2022. In general, geopolitical conflicts will harm the global economy (Hudecová and Rajčániová, 2023). In the case of Russia and Ukraine, the war significantly damaged productive assets, agricultural land, labour availability, roads, and other civilian infrastructure, with farmers unable to tend to their fields or harvest them (Feng et al., 2023). Hence, this war caused a welfare decline of 15–25% for most of the affected countries. The war will also leave 1.7 billion people hungry and 276 million people in severe food insecurity (Lin et al., 2023). Food prices see a sharp rise in 2022 by concentrating on a select few commodities, most of which are reliant on Ukraine (Arndt et al., 2023). For example, in the worst-case scenario, the conflict resulted in a 60% decline in wheat trade, a 50% increase in wheat prices, and severe food insecurity with a 30% decline in wheat purchasing power, particularly for countries that heavily rely on wheat imports from Ukraine, like Egypt, Turkey, Mongolia, Georgia, and Azerbaijan (Lin et al., 2023).

This war is even more dangerous because many countries have imposed sanctions on Russia. In fact, these sanctions hurt not only the Russian economy but also the whole world. Global inflation soared as a result of a substantial increase in the price of oil and gas (Yatsiv et al., 2023). The war also resulted in actual GDP declines in other countries. Rwanda and Myanmar experienced very significant real GDP losses due to stagnant agricultural export prices and a reliance on imported inputs for a substantial portion of production (Arndt et al., 2023).

In fact, there have been many studies examining the adverse effects of the Covid-19 pandemic and the Russia-Ukraine war on food prices, but this study is the first to separate the impact of each of these phenomena on global staple food. According to a study by Nugroho and Masyhuri (2024), both events raise food prices regionally, but it is unclear how they will affect the global community as a whole. Whereas, current food prices are the result of the interaction of numerous global shocks occurring at the same time.

The findings of this study are crucial for effective decision-making in the food business and food policy by investors, portfolio managers, and governments. It is important to examine the current crisis to get better prepared for future similar emergencies and have complex implications for human life. In addition, Covid-19 and the Russia-Ukraine war are likely to jeopardize the achievement of the Sustainable Development Goals (SDGs): no poverty, zero hunger, and responsible consumption and production.

1 LITERATURE REVIEW AND HYPOTHESIS

Food prices rose dramatically in 2008 as a result of several concurrent crises, including the global energy and financial crises (El Montasser et al., 2023). Economic theory suggests that energy, transportation, and fertilizer prices are influenced by oil price volatility; indicating the dependence of agriculture on crude oil (Shiferaw, 2019). Food prices have risen due to disruptions to global oil supply in countries without adequate oil reserves or efficient distribution systems. An increase in transportation costs as a result of rising oil prices also increases food prices (Dalheimer et al., 2021). Increasing energy prices and mitigating climate change also encourage the use of renewable energy derived from several staple food crops such as corn, soybeans, and wheat (biofuel). As a result of the conversion of food into fuel, there will be less food availability. In the meantime, as the world's population grows, so does the demand for food, which raises food prices owing to a lack of availability (Zimmer and Marques, 2021).

Hypothesis 1: changes in crude oil prices increased global wheat, maize, soybean, and rice prices.

The increase in food prices was also affected by increases in production factor prices, including fertilizers whose prices continued to increase and higher production costs as well. In addition, increases in fertilizer prices lead to lower yields as producers use less or no fertilizer. This is one reason for the high prices of agricultural products. Sugar, soybeans, and cotton were the crops most vulnerable to the effects of external shocks (Uçak et al., 2022).

Hypothesis 2: changes in urea prices increased global wheat, maize, soybean, and rice prices.

Furthermore, economic policy is also an important factor in determining food prices. Economic policy uncertainty has gained more attention from policymakers in recent years. Economic policy uncertainty appears to be the long-run and permanent cause of food price volatility (Kirikkaleli and Darbaz, 2022). Economic policy uncertainty also has a greater negative impact on food security (Su et al., 2023). This phenomenon occurs when commodities are sensitive to changes in the market, especially historical market demand and supply under low and high volatility regimes (Ahmed and Sarkodie, 2021). For example in the food case, wheat and maize prices were more negatively impacted by economic policy uncertainty than positively, and soybean prices were more favourably impacted than negatively (Long et al., 2023). Meanwhile, a 1% decrease in economic policy uncertainty reduces the global price of rough rice by 0.087% in the US-China trade war period (Hudecová and Rajčániová, 2023). The trade war has had the biggest impact on soybean volatility. This is hardly surprising considering that soybeans, followed by coffee and cotton, make up the majority of US agricultural exports to China (Cheng et al., 2023).

Hypothesis 3: global economic policy uncertainty increased global wheat, maize, soybean, and rice prices.

Apart from economic factors, food prices are also affected by the condition of natural resources and climate change. The effects of temperature rise on agriculture have been increasing over time and are unpredictable, with their severity reflected in the limited scale of agricultural production (Köse and Ünal, 2022; Omotoso et al., 2023). The decrease in production has an impact on creating an imbalance in food demand and supply, increasing prices, reducing household consumption, threatening food security, reducing consumer surplus, and declining GDP and well-being (Abeysekara et al., 2023; Kan et al., 2023). Unfortunately, the detrimental effects of climate change have not been successfully managed because farmers have limited access to climate information and lack knowledge of mitigation strategies (Tasnim et al., 2023). Consequently, there is a chance that temperature change will eventually result in higher food prices.

Hypothesis 4: temperature change increased global wheat, maize, soybean, and rice prices.

Recently, two significant occurrences – Covid-19 and the Russia-Ukraine war – have both affected the food supply chain. The Covid-19 pandemic influenced the entire food system, resulting in reduced agricultural inputs, fewer agriculture extension workers providing in-person assistance, income losses, higher food prices, and a decline in food security and dietary diversity. Farmers had difficulties getting agricultural inputs like fertilizer because of lockdowns and international price increases. As a result, the World Bank forecasted that the Covid-19 pandemic could lead to a decline in agricultural production by 2.6% to 7% and a 13–25% decline in food imports (McCann et al., 2023). Farmers were also severely restricted in their ability to move as a result of lockdowns, making it more difficult for them to deliver essential and basic staple food (Gutiérrez-Romero, 2022).

Food processing has also been impacted by Covid-19 because of rising food processing costs, declining supply chain trust, a lack of transparency and traceability, the dissemination of fake information, sluggish communication between supply chain participants, delays in advancing supply chain technologies, and frequent changes in food processing planning (Paul et al., 2023). Poor resource management and planning puts businesses and communities at risk of overspending and financial crises (Yetkin Özbük et al., 2022). The food processing sector is also facing fluctuating market demand and supply/raw material shortages (Paul et al., 2023).

Covid-19 cases significantly and positively affect food prices in India, South Africa, and China in the long run. In contrast, Covid-19 harmed food prices in every country in the short run except for Russia and Turkey (Chang et al., 2022). It's interesting to note that the rise in food prices also happened in countries like Solomon where there were no cases of Covid-19 reported. This is a result of the country's reliance on food imports and lockdowns (Farrell et al., 2023).

Hypothesis 5: Covid-19 increased global wheat, maize, soybean, and rice prices.

After the pandemic, the world again faced a crisis due to the Russia-Ukraine war. The supply of food, fuel, and fertilizer in global markets is much lower in end of April 2022 than it should be due to this war (Arndt et al., 2023). Russia is one of the world's fertilizer producers, so the war prevented this country from exporting fertilizer to the world market optimally. Russia accounts respectively for 23%, 21%, 14%, and 10% of ammonia, potash, urea, and processed phosphate exports worldwide (Feng et al., 2023).

The war had also a detrimental effect on global grain security, which decreased from 0.538 to 0.419 (Xu et al., 2023). The war resulted in damage to agricultural production, storage, and processing facilities as well as the loss of productive regions due to occupation or active warfare. The movement of Ukrainian grain to global markets was also nearly stopped by the blockade of Ukrainian ports that was conducted at the beginning of the war (Hussein and Knol, 2023). If Russia and Ukraine cut their wheat exports by 50%, grain prices may rise by 15%. This would result in an 8% fall in grain consumption and dietary energy intake (Mottaleb et al., 2022). This is very dangerous considering how dependent many developing countries in Asia and Africa are on Russian and Ukrainian wheat supplies (Nasir et al., 2022). Additionally, several countries have banned imports from Russia, which has resulted in a lack of food supplies globally (Mottaleb et al., 2022).

Besides that, the lack of fertilizer supply in global markets causes the price increase and some farmers may choose to use less of this production factor, which lowers agricultural output and drives up food prices (Arndt et al., 2023). Food price shocks affect geoprocessing more severely and directly since they drive up the price of imported inputs (such as domestic grain milling) (Arndt et al., 2023).

Hypothesis 6: the Russia-Ukraine war increased global staple food prices (wheat, maize, soybean, and rice).

2 MATERIAL AND METHODS

2.1 Theory and variable selection

Inflation was associated with excessive monetary growth, namely the money supply grows faster than the rate of growth in real output. However, non-monetary experts link inflation to a consequence of rising costs and prices to maintain high levels of production and employment. That is, regardless of demand, prices will only rise when costs do as well. This is known as the "cost-push" theory. According to this theory, producer costs and ultimately prices rise as a result of sellers of productive inputs (including labour) increasing their selling prices continually and unilaterally (Batten, 1981).

The development of the "cost-push" theory claims that the main sources of inflation include the competitive struggle for relative income shares, labour and capital immobility (and the resulting wage/price rigidities), a lack of job information, and "ratchet effects" resulting from specific prices' inflexibility to changes in the structure of demand (Batten, 1981). Recent global economic conditions indicate that the drivers of inflation are random non-monetary shocks (special factors) such as disease (Chang et al., 2022) and war (Nasir et al., 2022).

2.2 Data source

This study employs monthly time series data. The secondary data was collected from January 1997 to June 2023 (318 data observations). The dependent variable in this study is the change in global wheat, maize, soybean, and rice prices (Table 1). This variable is calculated from the percentage of price change compared to the previous month.

There are 6 explanatory variables in this study: change in crude oil price, change in urea price, global economic policy uncertainty index, temperature change, Covid-19 global case, and Russia-Ukraine armed clashes. Changes in crude oil price and changes in urea price are the percentage of price change compared to the previous month. The global economic policy uncertainty index is an index that quantifies economic uncertainty regarding future policies, taxes, the consumer price index, and government spending (Kirikkaleli and Darbaz, 2022). Temperature change explains annual statistics on the average surface temperature change by country. Covid-19 global case is the number of people confirmed positive for Covid-19. The more cases of positive people for Covid-19 indicate the pandemic is getting worse. Russia-Ukraine armed clashes are the number of armed clashes that occurred between Russia and Ukraine. The more armed clashes indicate the higher the intensity of the war.

Table 1 Variable in this study

Variable	Symbol	Source	Expected sign.
Changes in wheat price (% US dollars per metric ton)	WHE	Indexmundi	Not available
Changes in maize price (% US dollars per metric ton)	MAI	Indexmundi	Not available
Changes in soybean price (% US dollars per metric ton)	SOY	Indexmundi	Not available
Changes in rice price (% US dollars per metric ton)	RICE	Indexmundi	Not available
Changes in crude oil price (% US dollars per barrel)	OIL	World Bank	+
Changes in urea price (% US dollars per metric ton)	UREA	Indexmundi	+
Global economic policy uncertainty index	GEPU	Economic policy uncertainty	+
Temperature change (^{0}C)	TEMP	FAO	+
Covid-19 global case (person)	COV	John Hopkins University	+
Russia-Ukraine armed clashes (total events)	ARM	The armed conflict location & event data project	+

2.3 Data analysis

The impact of Covid-19 and the Russia-Ukraine war on global food prices every year (t) will be assessed using the model:

$$Y_t = A_0 + A_1 OIL_t + A_2 UREA_t + A_3 GEPU_t + A_4 TEMP_t + A_5 COV_t + A_6 ARM_t + \varepsilon_i \, , \tag{1}$$

where: Y is the global wheat or maize or soybean or rice price.

Most macroeconomic series are non-stationary, causing spurious regression. The analysis models that are suitable for solving this problem are the Error Correction Model (ECM) and Autoregressive Distributed Lag (ARDL). ECM can be used for models that are stationary at the first or second difference, but ARDL can only be used when all of the variables in the model are stationary at the first difference. Therefore, the first step taken in this study was the unit root test to determine the variable's stationarity. This test can prevent a regression model from creating "t-ratios" that do not follow a typical t-distribution and spurious regression. The Augmented Dicky Fuller (ADF) was used to analyse the unit root. The results of the unit root analysis show variations between variables (Table 2). The WHE, MAI, SOY, RICE, OIL, UREA, TEMP and COV are stationary at the level but GEPU and ARM are not stationary at that level. The non-stationary variables can be made stationary by taking the first and second differences. As a result, GEPU is stationary at the 1st difference and ARM is stationary at the 2nd difference. Based on the unit root test results, this study will use ECM.

Table 2 Unit root test

Variable	Level	Sig.
WHE	At level	–14.279***
MAI	At level	–13.942***
SOY	At level	–14.331***
RICE	At level	–11.428***
OIL	At level	–13.663***
UREA	At level	–15.192***
GEPU	1st difference	–14.079***
TEMP	At level	–6.368***
COV	At level	–7.768***
ARM	2nd difference	–5.886***

Note: *** sig at 0.01.
Source: Secondary data analysis

The relationships between non-stationary variables must be examined using a cointegration test. Cointegration is defined as (i) heterogeneity, (ii) imbalanced panels, (iii) cross-sectional dependency, (iv) cross-unit cointegration, and (v) asymptotic N and T (Im et al., 2003). The Johansen cointegration test was used in this study to compare the trace statistic and maximum eigenvalue values for cointegration. The Johansen cointegration equation is shown (Shrestha and Bhatta, 2018):

$$Y_t = A_1 Y_{t-1} + \varepsilon_t \, , \tag{2}$$

so that:

$$\Delta Y_t = A_1 Y_{t-1} - Y_{t-1} + \varepsilon_t \tag{3}$$

$$= (\mathrm{A}_1 - \mathrm{I})\ Y_{t-1} + \varepsilon_t\,, \tag{4}$$

can be written as:

$$= \Pi Y_{t-1} + \varepsilon_t\,, \tag{5}$$

where: Y_t and ε_t are (n.l) vectors, A_1 = an (n.n) matrix of parameters, I = an (n.n) identify matrix $\Pi = A_1 - I$.

The hypothesis of the test:

$H_0 : A_i = A_0$, there is no cointegration,
$H_a : A_i \neq A_0$, there is a cointegration.

The cointegration test results show that variables in every model have a long-run relationship (Table 3). This means that the WHE or MAI or SOY or RICE, OIL, UREA, GEPU, TEMP, COV, and ARM variables are cointegrated. It is indicated by the trace statistics value being higher than the critical value at the 1% and 5% confidence levels (Ender, 1995).

Table 3 Cointegration test of every model

Hypothesized No. of CE (s)	WHE	MAI	SOY	RICE
None	342.738***	364.499***	357.031***	352.505***
At most 1	244.566***	263.638***	258.347***	237.488***
At most 2	161.194***	170.447***	169.705***	158.945***
At most 3	101.797***	109.678***	112.262***	106.070***
At most 4	56.037***	59.685***	60.499***	59.324***
At most 5	13.907**	14.821**	15.486**	16.127**
At most 6	4.456**	4.820**	5.017**	4.432**

Note: *** sig 0.01, ** sig 0.05.
Source: Secondary data analysis

The long-run relationship or equilibrium of various variables is shown by cointegration. However, the economic variables in this study frequently experience disequilibrium in the short-run. That is, what economic actors want is not always the same as what occurs. These differences necessitate adjustments to correct for disequilibrium, which are known as error correction models (ECM) in econometrics. The estimation of the ECM equations is as follows:

$$EG_t = Y_t - A_0 - A_1 OIL_t - A_2 UREA_t - A_3 GEPU_t - A_4 TEMP_t - A_5 COV_t - A_6 ARM_t\,, \tag{6}$$

where: EG_t is a disequilibrium error.

The dependent and explanatory variables are rarely in equilibrium, so it is necessary to observe the disequilibrium relationship by including the element of lag. In this study, the variables used are not stationary at the levels so the equation becomes:

$$Y_t - Y_{t-1} = a_0 + a_1 OIL_t + a_2 OIL_{t-1} + a_3 UREA_t + a_4 UREA_{t-1} + a_5 GEPU_t + a_6 GEPU_{t-1} + a_7 TEMP_t + a_8 TEMP_{t-1} + a_9 COV_t + a_{10} COV_{t-1} + a_{11} ARM_t + a_{12} ARM_{t-1} - (1-\Phi)\, Y_{t-1} + e_t\,. \quad (7)$$

Adding and subtracting with $a_n X_{t-1}$ on the right side of Formula (7) gives:

$$Y_t - Y_{t-1} = a_0 + a_1 OIL_t - a_1 OIL_{t-1} + a_1 OIL_{t-1} + a_2 OIL_{t-1} + a_3 UREA_t - a_3 UREA_{t-1} + a_3 UREA_{t-1} + a_4 UREA_{t-1} + a_5 GEPU_t - a_5 GEPU_{t-1} + a_5 GEPU_{t-1} + a_6 GEPU_{t-1} + a_7 TEMP_t - a_7 TEMP_{t-1} + a_7 TEMP_{t-1} + a_8 TEMP_{t-1} + a_9 COV_t - a_9 COV_{t-1} + a_9 COV_{t-1} + a_{10} COV_{t-1} + a_{11} ARM_t - a_{11} ARM_{t-1} + a_{11} ARM_{t-1} + a_{12} ARM_{t-1} - (1-\Phi) Y_{t-1} + e_t\,. \quad (8)$$

Formula (8) also can be written:

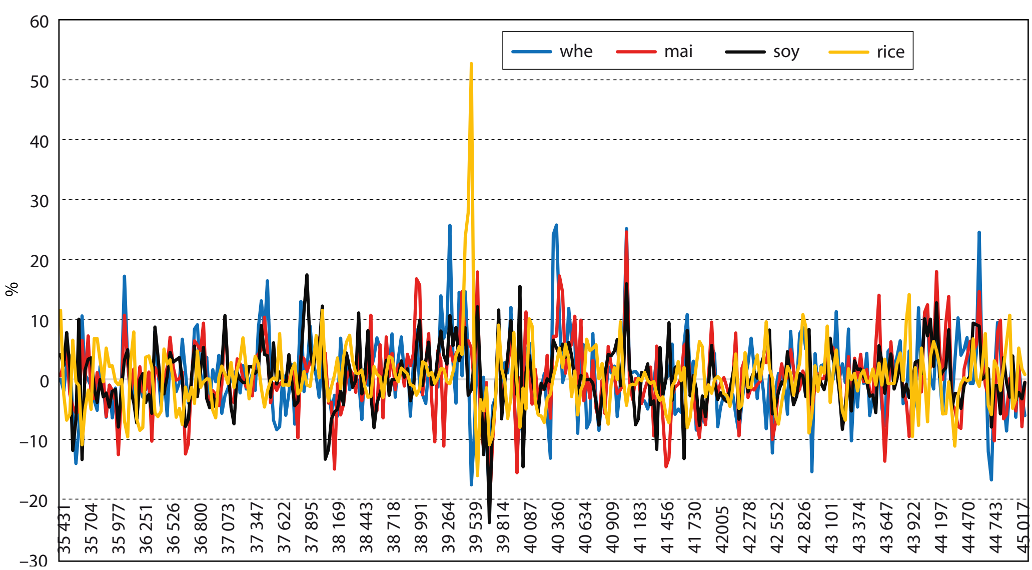
$$\Delta Y_t = a_0 + a_1 \Delta OIL_t + (a_1 + \alpha_2) OIL_{t-1} + a_3 \Delta UREA_t + (a_3 + a_4) UREA_{t-1} + a_5 \Delta GEPU_t + (a_5 + \alpha_6) GEPU_{t-1} + a_7 \Delta TEMP_t + (a_7 + a_8) TEMP_{t-1} + a_9 \Delta COV_t + (a_9 + a_{10}) COV_{t-1} + a_{11} \Delta ARM_t + (a_{11} + a_{12}) ARM_{t-1} - \lambda Y_{t-1} + et\,, \quad (9)$$

where: Δ = first difference and $\lambda = 1 - \Phi$.

3 RESULTS

Global food prices fluctuated significantly between January 1997 and June 2023. Figure 1 shows that the highest price increase was for rice in April 2008. In recent years, food prices have fluctuated dramatically in the world, especially during the Covid-19 pandemic and the Russia-Ukraine war. Both phenomena

Figure 1 Monthly change in global staple food prices January 1997–June 2023



Source: Indexmundi

have caused wheat prices to rise by 24.53% (March 2022), corn by 14.66% (March 2022), soybeans by 9.14% (February 2024), and rice by 10.71% (January 2023).

The ECM analysis of the determinant factors of the global wheat price change (WHE) is considered valid because the RESID probability is less than 0.05 (Table 4). Changes in the price of urea fertilizer (UREA) and armed clashes (ARM) are two factors influencing WHE in the short-run. A 1% rise in UREA reduces WHE by 0.063%, while ARM event increases WHE by 0.0002%. However, both variables have no long-run effect on WHE. Only fluctuations in global oil prices (OIL) and the Covid-19 global case (COV) have a long-run impact on WHE. WHE increases by 0.0733% and 0.00000003% for every 1% rise in OIL and 1 COV person, respectively. Two explanatory variables, the global economic policy uncertainty index (GEPU) and temperature change (TEMP), have no significant impact on WHE either in the short or long run.

Table 4 Determinant factors of the global wheat prices in the short-run and long-run

Variable	Short-run		Variable	Long-run	
	Coef.	Std. error		Coef.	Std. error
D(OIL)	0.052 (1.263)	0.041	OIL	0.0733* (1.811)	0.040
D(UREA)	−0.063** (−2.235)	0.028	UREA	−0.038 (−1.250)	0.030
D(GEPU)	−0.00007 (−0.423)	0.0002	GEPU	0.000002 (0.025)	0.00006
D(TEMP)	−0.007 (−0.519)	0.013	TEMP	−0.003 (−0.279)	0.011
D(COV)	0.00000002 (1.274)	0.00000002	COV	0.00000003** (2.161)	0.00000001
D(ARM)	0.0002** (2.075)	0.00009	ARM	−0.00005 (−1.370)	0.00004
RESID(−2)	−0.242*** (−3.445)	0.070			
C	−0.0006 (−0.131)	0.005	C	0.006 (0.530)	0.012
Adj. R squared		0.5590	Adj. R squared		0.3303
F-statistic		3.664***	F-statistic		7.705***

Note: *** sig 0.01, ** sig 0.05, * sig 0.1.
Source: Secondary data analysis

The first variable to be observed in Table 5 is RESID, where the probability is less than 0.05, indicating that the model is valid. Meanwhile, when it comes to the variables that influence global maize prices (MAI), only two are significant: OIL and COV. A 1% increase in OIL raises MAI in the short-run by 0.078% and in the long-run by 0.102%. The MAI will increase by 0.00000002% in the long run due to a 1 person increase in COV. The other explanatory variables, UREA, GEPU, TEMP, and ARM do not have a significant impact on MAI in both the short and long run.

The analysis finding of global soybean prices (SOY) is the same as MAI, namely only OIL and COV which have a significant effect (Table 6). A 1% increase in OIL raises SOY in the short-run by 0.098% and in the long-run by 0.115%. The SOY will increase by 0.00000002% in the long run due to a 1 person increase in COV. Meanwhile, the RESID probability is less than 0.05 so the model can be declared valid. UREA, GEPU, TEMP, and ARM do not have a significant impact on SOY in both the short and long run.

Table 5 Determinant factors of the global maize prices in the short-run and long-run

Variable	Short-run		Variable	Long-run	
	Coef.	Std. error		Coef.	Std. error
D(OIL)	0.078** (2.116)	0.037	OIL	0.102*** (2.771)	0.037
D(UREA)	–0.041 (–1.578)	0.026	UREA	–0.014 (–0.519)	0.028
D(GEPU)	0.00009 (0.562)	0.0002	GEPU	–0.000001 (–0.018)	0.00006
D(TEMP)	–0.010 (–0.891)	0.012	TEMP	0.0006 (0.066)	0.010
D(COV)	0.00000001 (0.616)	0.00000002	COV	0.00000002* (1.880)	0.00000001
D(ARM)	0.00006 (0.727)	0.00008	ARM	–0.00004 (–1.273)	0.00003
RESID(–2)	–0.225*** (–3.211)	0.070			
C	–0.0003 (–0.074)	0.004	C	0.002 (0.223)	0.010
Adj. R squared		0.3971	Adj. R squared		0.2356
F-statistic		2.861**	F-statistic		2.275***

Note: *** sig 0.01, ** sig 0.05, * sig 0.1.
Source: Secondary data analysis

Table 6 Determinant factors of the global soybean prices in the short-run and long-run

Variable	Short-run		Variable	Long-run	
	Coef.	Std. error		Coef.	Std. error
D(OIL)	0.098*** (2.963)	0.035	OIL	0.115*** (3.599)	0.032
D(UREA)	–0.029 (–1.281)	0.023	UREA	–0.007 (–0.291)	0.024
D(GEPU)	–0.00007 (–0.492)	0.0001	GEPU	–0.00002 (–0.357)	0.00005
D(TEMP)	0.009 (0.860)	0.011	TEMP	0.006 (0.753)	0.008
D(COV)	–0.000000003 (–0.204)	0.00000001	COV	0.00000002* (1.693)	0.00000001
D(ARM)	0.00001 (0.164)	0.00008	ARMC	–0.00003 (–1.172)	0.00003
RESID(–2)	–0.167** (–2.306)	0.073			
C	–0.0001 (–0.038)	0.004	C	–0.002 (–0.262)	0.009
Adj. R squared		0.2719	Adj. R squared		0.4048
F-statistic		2.258**	F-statistic		3.229***

Note: *** sig 0.01, ** sig 0.05, * sig 0.1.
Source: Secondary data analysis

The probability of RESID is less than 0.05 so the global rice prices model (RICE) can be stated as valid (Table 7). A 1% increase in UREA results in a 0.049% increase in RICE in the short-run and a 0.084% increase in the long-run. OIL, GEPU, TEMP, COV, and ARM do not have a significant impact on RICE in both the short and long run.

Table 7 Determinant factors of the global rice prices in the short-run and long-run

Variable	Short-run		Variable	Long-run	
	Coef.	Std. error		Coef.	Std. error
D(OIL)	−0.018 (−0.602)	0.030	OIL	−0.014 (−0.400)	0.035
D(UREA)	0.049** (2.311)	0.021	UREA	0.084*** (3.196)	0.026
D(GEPU)	−0.00005 (−0.389)	0.0001	GEPU	−0.00001 (−0.191)	0.00005
D(TEMP)	−0.012 (−1.279)	0.010	TEMP	0.006 (0.702)	0.009
D(COV)	0.00000001 (1.288)	0.00000001	COV	0.000000006 (0.484)	0.00000001
D(ARM)	0.00005 (0.687)	0.00007	ARM	0.00002 (0.672)	0.00003
RESID(−2)	−0.350*** (−5.734)	0.061			
C	0.00002 (0.006)	0.003	C	−0.004 (−0.443)	0.010
Adj. R squared		0.3052	Adj. R squared		0.1745
F-statistic		6.289***	F-statistic		2.438**

Note: *** sig 0.01, ** sig 0.05.
Source: Secondary data analysis

Based on the findings, several explanatory variables support and do not support the hypothesis of this study (Table 8).

Table 8 Supported or Unsupported the hypothesis of this study

Variable	Wheat	Maize	Soybean	Rice
OIL	Supported	Supported	Supported	Unsupported
UREA	Unsupported	Unsupported	Unsupported	Supported
GEPU	Unsupported	Unsupported	Unsupported	Unsupported
TEMP	Unsupported	Unsupported	Unsupported	Unsupported
COV	Supported	Supported	Supported	Unsupported
ARM	Supported	Unsupported	Unsupported	Unsupported

Source: Secondary data analysis

4 DISCUSSIONS

4.1 Impact of Covid-19 and Russia-Ukraine war on global staple food prices

Covid-19 has no significant effect on global staple food prices in the short-run but is significant in the long-run. In the short-run, many countries made wise decisions to impose lockdowns to stop the spread of Covid-19. Therefore, global staple food prices are not affected by the lockdown and the government's strict measures. For example, Brazil, Russia and Turkey may have made wise decisions to handle Covid-19 cases to prevent the consequences of Covid-19 on food prices in these countries (Chang et al., 2022). However, the Covid-19 pandemic has disrupted the production and supply chain management of wheat, maize, and soybean in the long-run. It is challenging for producers to get agricultural inputs and information. The use of chemical fertilizers is decreasing due to rising prices (Hammad et al., 2023). Marketers are unable to deliver products to consumers due to restrictions or lockdowns. These restrictions have also caused that farmers were unable to plant and harvest their crops on time due to a lack of labour and huge machinery (Rajpoot et al., 2022). In the food processing subsystem, there are more expenses, less transparency and traceability, rising raw material costs, a shortage of capital and physical resources, and the spread of fake information (Paul et al., 2023).

The Covid-19 pandemic has also delayed and increased the cost of food delivery resulting in a shortage of supply in the market. By October 2021, indicators of container shipping costs via maritime freight soared by more than 500% from pre-pandemic levels (Carrière-Swallow et al., 2023). As a result, people take part in panic buying and stocking up because they worry about running out of food and processing bottlenecks (Bai et al., 2022). Additionally, many informal and wholesale food markets were shut down, making it impossible for people to earn their daily bread, leaving the population's necessities and facing the actual risk of going without enough to eat (Gutiérrez-Romero, 2022).

The phenomenon can be seen in all countries causing an increase in food prices more than usual price (Rajpoot et al., 2022) and following our study. Covid-19 and lockdown measures are impacting changes in supply and demand in the food market, which can have an impact on food prices (Chang et al., 2022). In January 2021, cereal prices were 45% higher, wheat prices were 23% higher, and maize prices were 66% higher than they were in January 2020. In April and May 2020, the real food price level reached a level of roughly 1.6% over January 2020 levels before progressively dropping and staying at 1.2 to 1.4% above January 2020 levels from September to December 2020. The most dramatic monthly price level increases occur for nuts, seeds, pulses, dairy, and eggs (Wallingford et al., 2023). On a smaller scale, the average retail and wholesale price of wheat in India increased by 0.11 and 0.28%, respectively, where supply interruption was more pronounced due to the higher incidence of Covid-19 (Cariappa et al., 2022). In Africa, a 10% rise in the price index is correlated with an increase in violence against civilians of 0.71% (Gutiérrez-Romero, 2022).

Food price fluctuations in each country are also caused by the failure of the government to implement policies in support of effective price stabilization (Onyango, 2023). As a result, a rise in consumer prices coupled with a negative income shock could decrease demand for wheat and heighten food insecurity (Cariappa et al., 2022).

Food prices are predicted to be more volatile due to a combination of declining maize and soybean supply forecasts and rising demand for feed grains from bonded livestock production in the East Asia, particularly China. This was exacerbated by the outbreak of the Russia-Ukraine war, sanctions imposed on Russia, and restrictions on the exports of major grain producers (Hammad et al., 2023). Worse, the rise in food prices in the first half of 2022 was also accompanied by an increase in the price of oil and fertilizer globally because of this war and the sanctions imposed on Russia (Arndt et al., 2023).

Together, Covid-19 and the Russia-Ukraine war's effects on the food system are resulting in a new type of food price crisis, in which agricultural production is largely unaffected but there is unusually high price volatility caused by significant swings in demand, with higher average retail prices resulting from the high costs of maintaining the off-farm supply chain (Bai et al., 2022).

Despite being terrible, the Russia-Ukraine war only had a short-run on global staple food prices. This is because the war only had a geographical impact, leaving many countries' crops unaffected. All countries consume wheat, maize, soybeans, and rice, although the reliance on imports from Russia and Ukraine varies substantially by crop and country. When viewed from the crops side, African countries are generally self-sufficient in maize as the continent's main staple food. Most Asian countries are also significant rice producers and are less dependent on imports (Arndt et al., 2023). Since Russia and Ukraine are not the world's major soybean producers, their conflict has no bearing whatsoever on global soybean prices (Nasir et al., 2022).

But the situation is different from wheat, where Russia and Ukraine are the main producers of this product. Our analysis shows that the war had a major impact on global wheat prices even in the short-run. Russia and Ukraine exported 49.9 MMT of the 199 MMT of wheat exported globally in 2021 or 25% of the total. The top three wheat-importing countries in 2021 will be Egypt, Indonesia, and China, which will collectively buy 32.5 MMT of wheat, or 16% of global wheat exports (Mottaleb et al., 2022). Hence, many countries rely heavily on imports and are feeling the impact of rising food prices (Nasir et al., 2022).

When looking at the countryside, not all regions are impacted by the rise in food prices brought on by this war. Measures of Russian geopolitical risk taken collectively reduce food prices in Eastern Europe temporarily but raise them in Western Europe. This depicts that the Eastern European block may depend mainly on its domestic cereal production to meet its food demand (Sohag et al., 2023).

Even so, we also need to consider the fact that Russia is an important producer of crude oil and fertilizers. Following the start of this war, each of these commodities saw price spikes, which significantly affected the food prices. This situation made people consider the need for further studies using global crude oil and urea prices as proxies between the Russia-Ukraine war and global staple food prices.

4.2 Impact of other factors on global staple food prices

Energy is found to be a permanent cause of the food price increases (Kirikkaleli and Darbaz, 2022). Our study findings are in line with the study Sohag et al. (2023) that rising global energy prices have raised food inflation. The relationship between both products is dynamic (time-varying) or exists both in the short and long-run (Shiferaw, 2019). Economic theory suggests that energy, transportation, and fertilizer prices are influenced by oil price volatility; indicating the dependence of agriculture on crude oil (Shiferaw, 2019).

Agricultural production requires a variety of modern machines fuelled by crude oil derivatives. Similarly, agricultural products must be distributed from producers to consumers using transportation which use machinery running on gasoline supplied by crude oil. Thus, rising oil prices raise the cost of both production and transport (Zimmer and Marques, 2021). In addition, wheat, corn, and soybeans can be used as both food and fuel. Most countries will move to utilize fuels from these three commodities if global oil prices rise. Hence, global food supplies will decline and its price will increase (Pal and Mitra, 2019). This phenomenon occurred regularly between 1987 and 2021: 14 occurrences of high price hikes for maize, 8 occurrences for soybeans, and 4 occurrences for wheat (El Montasser et al., 2023).

The correlation between oil prices and food prices can be seen in several situations. The Libyan revolution and the oil embargo on Iran are largely to blame for the increase in corn prices in 2011 and 2012. In contrast, corn prices were under pressure in 2014–15 due to the US oil boom and an increase in Middle East oil production. Finally, political developments that affect the oil market, such as hostilities between the US and Iran or more recently, the Saudi Arabian-Russian oil price conflict, have the potential to raise or lower corn prices by up to 25% (Dalheimer et al., 2021).

Apart from oil prices, changes in urea prices also affect global staple food prices. Urea fertilizer ensures the availability of nitrogen in the soil, allowing for optimal rice growth (Giordano et al., 2021). The use of urea fertilizer helps the process of forming chlorophyll and the process of rice photosynthesis, resulting in increasing production (Gholizadeh et al., 2017). This causes farmers' reliance on urea fertilizer to keep growing, especially in developing countries. This reliance makes farmers to reduce their use of fertilizers or not use them when the price of urea increases. According to Elser et al. (2014), there is a linear relationship between the urea fertilizer price and the rice price. As a result, rice production will decrease and prices will increase at the global level (Uçak et al., 2022). This problem is made worse by the inefficient use of urea fertilizer so that the rice productivity is 20% lower than it should be (Nayak et al., 2022). In contrast to rice, the price of wheat declines when the price of urea fertilizer rises. This plant is frequently grown in developed countries that have successfully used urea in efficient ways (Cui et al., 2023). Due to this circumstance, there is less risk of urea loss and more soil nitrogen is available (Yang et al., 2018).

In our study, 2 explanatory variables do not affect global staple food prices. First. Global economic policy uncertainty (GEPU). This result is the same as that in the study by Hudecová and Rajčániová (2023) which showed GEPU had no significant effect on food prices. For example, the long-run impact of GEPU on rice prices is not significant (Long et al., 2023). The main cause of this phenomenon is the current situation of events' low sensitivity of food commodities to external shocks that are not essential to crops (Ahmed and Sarkodie, 2021). This argument is also strengthened by Wang et al. (2023), the returns on corn and soybeans have proven to be able to respond to the current low macroeconomic uncertainty. In addition, staple crops, especially soybeans, soybean meal, and maize, have shown high-value investing in market recovery procedures and engaging in market hedging activities, which bring a lower risk of spillovers from GEPU (Jiang et al., 2023).

Second, temperature. Temperature changes have the potential to reduce the production of wheat, corn, soybeans, and rice. However, adaptation and mitigation actions have been implemented quickly and strictly to reduce the detrimental impacts of climate change (Köse and Ünal, 2022). This strategic action must be supported by further integrated programs such as government subsidies and aids so that it is effective in increasing food production and reducing food prices without harming farmers' livelihoods (Yan and Alvi, 2022). For example, the Chinese government's policy of supporting rice prices helped determine the rice projected price, and the price elasticities of rice and maize on rice yields were 0.194 and –0.097, respectively (Yu et al., 2022). Key adaptation strategies identified were also increasing irrigation, switching to other crops, and changing fertilizer and insecticide usage (Tasnim et al., 2023). Hence, the temperature does not affect the global staple food price again.

CONCLUSION AND POLICY IMPLICATION

The aim of our study is to compare the negative impact of Covid-19 and the Russia-Ukraine war on global staple food prices. The results of this study show that Covid-19 has a more dangerous impact on global staple food prices than the Russia-Ukraine war. Covid-19 raises the price of wheat, maize, and soybean in the long run. This phenomenon is very natural because this pandemic and its control measures (lockdowns) are happening in all countries. Meanwhile, the Russia-Ukraine war caused an increase in the price of wheat in the short-run but not for other food commodities. The reason is that Russia and Ukraine are the global main wheat producers. This war is also a geopolitical issue so that other countries can produce food as usual and fulfil the global food shortage.

Our study also proves the relevance of the "cost-push" theory, a theory that has been around for a long time, with the current condition of factual inflation. Food prices increased because of higher prices for crude oil and urea, especially related to production and transportation costs.

We suggest some important points regarding this study for our future. First, each country must be transparent in reporting disease outbreaks in their country to prevent future pandemics. The spread of the disease will not cause economic turbulence in the future if it is handled quickly and precisely, for example, vaccination, limiting human movement, followed by assistance with production factors for producers and food aid for consumers. Second, the wise use of renewable energy as an alternative to crude oil, such as wind, geothermal, water, and plants. Another alternative is the use of electric vehicles and reducing fuel subsidies. This is to reduce losses from global crude oil price fluctuations. Third, the use of organic fertilizers reduces dependence on chemical fertilizers and their price fluctuations. This is done by utilizing organic household and livestock waste and establishing an organic fertilizer factory. Fourth, each country needs to optimize domestic resources to increase food production and dependency on other countries. This step is carried out by increasing the efficiency of agricultural production, distribution, and markets. Fifth, a need for the role of investors in the development of the food industry, renewable energy, and organic fertilizers. The government in each country must make policies to facilitate investment and ensure domestic social, political, and economic stability. Sixth, each country exercises restraint and places a high value on diplomacy when resolving disputes. The globe suffers tremendous losses because of war, both in terms of human lives lost and socioeconomic costs. The implementation of sanctions has proven to worsen regional and global economic conditions.

The price-shock is a good indicator of the vulnerability of the global food supply system. Due to this, we must re-consider the mainstream development strategy. From this point of view, there are two critical points: the non-food use of agricultural raw materials (e.g. bio-ethanol, bio-diesel projects) and the (over) emphasis on organic production. The energy use of agricultural products will decrease the material basis of the food supply, and the efficiency of organic production is much lower than the efficiency of modern agriculture. This can be further enhanced by the wide-range application of precision agricultural technologies.

As a summary it can be concluded, that the globe suffers tremendous losses because of war, both in terms of human lives lost and socioeconomic costs. The implementation of sanctions has proven to worsen regional and global economic conditions.

The main limitation of this study is that it ignores how the Russia-Ukraine War has affected the rising prices of crude oil and urea. Russia is a major producer of crude oil and fertilizers, whereas in our study the elasticity of food prices is higher under price increases for both than under other situations. The effects and consequences of climate change we have approximated by temperature, but the effect of drought is very important, too. This should also be included in the more sophisticated models. Therefore, we recommend that future research use the price of crude oil and fertilizers as a proxy between the Russia-Ukraine war and the increase in food prices. This modification will promote the application of simultaneous least squares, a new analysis model. This model avoids endogeneity issues, ensuring the validity and credibility of the analysis results.

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