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Impact of Global Economic Uncertainty, Climate Change, Covid-19, and the Russia-Ukraine War on Indonesian Food Prices

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Abstract: Food prices have continued to increase in recent years for various reasons. This study aims to investigate the simultaneous impact of global economic uncertainty, climate change, Covid-19, and the Russia-Ukraine war on food prices in Indonesia. The error correction model was used to examine data from July 2012 to December 2022. Global food prices, climate change, Covid-19, the Russia-Ukraine war, and consumer confidence raise food prices in the long run. In contrast, global energy prices, interest central bank rates, and real broad effective exchange rates have the reverse effect. According to the analysis, climate change has the worst effect on food prices in Indonesia.

Keywords: consumer confidence index; error correction model; interest rate; real exchange rate.

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1. Introduction

Global food demand will rise because of population growth, and agriculture will be critical in ensuring food security. As a result, various technological innovations, infrastructures, and policies, including subsidies, improved marketing, finance, and research and extension services were implemented to ensure the success of this initiative. However, the beneficial effect of these efforts appears to have been diminished in recent years by rising food prices, even though the increase in food prices has hampered the achievement of the Sustainable Development Goals.

The first failure relates to achieving Goal 2: no hunger. Global food price volatility is a significant concern since it jeopardizes the food security of a substantial part of the worldwide population. Rising food prices have also increased worries about food systemic crises, reducing consumers' purchasing power, particularly among low-income and impoverished populations that rely on agriculture (Zhou and Chen, 2023). The second failure is to avoid poverty (Goal 1). Rising food prices encourage people to spend more of their money on food. As a result, individuals no longer have enough money to cover their basic needs following their eligibility standards.

Agricultural and food prices were greater in 2020 than 2004, indicating a long-term pattern of growing relative food prices (Flexor et al., 2023). This is critical because higher prices hurt food consumers, and food price transmission increases domestic food price volatility, increasing-price uncertainty (Flachsbarth and Garrido, 2014). For example, for every 10% increase in global food prices, 33% of the fluctuation is carried through to

Zimbabwe's headline inflation. A 10% increase in South Africa's CPI, Zimbabwe's trading partner, could cause inflation to reach 228% (Mhonyera et al., 2023).

The Indonesian government has launched several programs, including food aid, to mitigate the detrimental impact of rising food prices. This initiative has demonstrated its ability to maintain public food consumption and preserve consumer purchasing power (Negi, 2022). However, many reports claim that government aid is inadequate. The distribution of necessities misses the most vulnerable groups, such as the urban poor and migrants. The consequences are that many urban poor suffer significantly from a lack of access to adequate food (Varma & Sutradhar, 2023).

The Indonesian government's inability to provide food aid evenly to the community will encourage the society to investigate the causes of food price volatility. The hope is that the government can overcome the emergence and impact of a phenomenon that threatens food price stability. Several researchers have studied the causes of food yield disruption and price changes in recent: Covid-19 (Zhou and Chen, 2023), Russia-Ukraine war (Nasir et al., 2022), climate conditions (Iliyasu et al., 2023), economic uncertainty (Widarjono et al., 2020; Chang et al., 2022), and domestic condition (Iddrisu and Alagidede, 2020). The main gap in that study is that it only considers changes in food prices caused by one of these factors. In fact, in the current situation, numerous factors affect the value of food prices. No researcher has ever conducted studies examining the combination of these factors.

Hence, this study aims to examine the simultaneous impact of global economic uncertainty, climate change, Covid-19, and the Russia-Ukraine war on food prices in Indonesia. This country was chosen for several reasons: 1) a huge population, thus fluctuations in food prices and economic turbulence will have a significant impact on people's lives (Neves, 2010), 2) the global primary producer of food, fertilizer, and fuel (Nasir et al., 2022), and 3) rapid economic growth (Neves, 2010).

The remainder of this article is organized into four sections: theory, literature review, and hypothesis (Section 2), the data collection and analysis process (Section 3), the data analysis results (Section 4), discussion of the study's findings (Section 5), and conclusions and recommendations from this study (Section 6).

2. Theory, Literature Review, and Hypothesis

2.1. Theoretical background

The current study views inflation as caused by a supply-demand imbalance during a period of global shock. On the supply side, the global shock has resulted in a product supply shortage in the market because of difficulties in carrying out production and distribution processes. During this time, new challenges arose, most notably increased production costs. Hence, the first inflation theory considered in this study is the cost-push theory. The origins of the cost-push theory can be traced back to Sir James Steuart's 1767. Steuart established at least three main strands of cost-push theory. The first was his view of the price level as a nonmonetary phenomenon determined by the same forces that govern prices for specific products. The second section of Steuart's cost-cutting ideology supplements the first. Prices are said to move independently of money because general prices are a genuine phenomenon. Steuart advanced two arguments to explain why money does not affect prices: idle hoards absorb excess coins from circulation just as they release additional coins into circulation to correct a monetary shortage, and changes in the stock of money that do spill over into the commodity market induce matching shifts in commodity demand and supply. The third strand of Steuart's cost-push doctrine follows logically from the second. After denying that money drives or influences prices, he contended that causation goes from prices to (velocity-augmented) money. Basically, this theory links inflation to growing production costs amid a continual demand flow. A rise in these "input costs" will almost certainly reduce a producer's profit. As a result, some producers may pass these additional expenses to the consumer by charging higher prices for

the same unit of products (Humphrey, 1998). We will use several variables related to global shocks to represent the cost-push theory.

On the demand side, the global shock has caused producers to be unable to meet consumer demand. The main reasons for this circumstance are difficulties in supplying products and consumer panic buying. As a result, the demand-pull theory of inflation was applied in this study. In this view, continued price increases result from demand-pull factors driven by monetary policy rather than cost-push pressures. According to this theory, inflation was driven solely by excessive demand, for which restrictive monetary policy was a suitable and, in effect, costless response (Schwarzer, 2018). Based on the demand-pull theory, I will include domestic monetary policy in this study.

2.2. Literature review and hypothesis

Food price inflation has been driven by the global economic recession, extreme weather events, geopolitical tensions, and their interconnected consequences (Chang et al., 2022). Food price inflation typically occurs when food supply fails to meet demand, or when food production and distribution costs rise because of weather, input costs, currency exchange rates, etc. In 2022, global commodity price inflation peaked at its highest in the previous two decades, raising concerns about a perfect storm of socioeconomic upheavals caused by the Covid-19 pandemic and the war in Ukraine, among other things (Zhou and Chen, 2023). Global food prices skyrocketed in 2022, particularly in March, one month after the Russia-Ukraine war. Global soybean prices increased by 8.91% in March, 0.03%, and 0.46% in April and May, respectively. Maize prices climbed faster than soybean prices, reaching 14.66% in March 2022, 3.77% in April 2022, and 0.95% in May 2022. Wheat has the highest price increase of any food product. This commodity's price increased by 24.53% in March, 1.85% in April, and 5.45% in May (Nasir et al., 2022). The rise in global food prices will be passed on to many countries, particularly importers, leading to a subsequent increase in local food prices.

Hypothesis 1: food prices will rise due to increases in global food prices.

The price of crude oil affects food prices via supply and demand. On the supply side, crude oil directly impacts agricultural commodity inputs via energy-intensive inputs such as fertilizer. The increase in global oil prices has also led to higher transportation costs, making food prices more expensive. On the demand side, the crude oil price crisis has caused the search for alternative inputs such as biofuels, increasing competition for agricultural commodities used for food and fuel. As a result, these commodities' prices will climb (Widarjono et al., 2020). For example, crude oil prices have a statistically significant impact on rice prices in China, with a 1% increase in crude oil prices increasing rice prices by 0.087%. Similarly, an increase in crude oil prices may lead to an increase in maize and soybean prices when more of these commodities are used for biofuels (Wang et al., 2015).

Hypothesis 2: food prices will rise due to increases in global energy prices.

Climate change reduces real output from its potential level and shifts the supply curve to the left, resulting in a fall in output supply and rises in food and general consumer prices (Iliyasu et al., 2023). Climate change will reduce agricultural productivity (between 2% and 15%) and raise food prices (between 1.3% and 56%) globally by 2050 (Delince et al., 2015). On a smaller level, climate change is projected to reduce food production in South Asia by up to 4%, 11%, and 7% by 2030 for rice, wheat, and cereal grains, respectively. Climate-induced agricultural production reductions are expected to pressure the region's food prices and security. Prices of rice, wheat, and other grains are predicted to climb at much higher rates, up to 10%, 25%, and 45%, respectively (Bandara and Cai, 2014). Despite more homes growing their food and having access to livestock, more households could not supply the appropriate amount of food for the entire household (Drysdale et al., 2021).

Hypothesis 3: food prices will rise due to climate change.

The Covid-19 pandemic is a new phenomenon that caused recurring disruptions in global supply chains, contributing to food price inflation through supply chain disruption and supply-demand imbalances (Zhou and Chen, 2023). On the supply side, farmers face challenges accessing their agricultural land for sowing, fertilization, pest control, and harvesting. Farmers and traders were perplexed by labors shortages and the shutdown of wholesale markets during the beginning days of the lockdown due to Covid-19 concerns (Cariappa et al., 2022). Many food businesses, such as bakeries and restaurants, have gone out of business due to bankruptcy or government restrictions (Kraus et al., 2020). Hence, food prices rose during the Covid-19 pandemic. For example, prices for red chili, onion, garlic, and chicken increased in Indonesia (Chang et al., 2022).

On the demand side, the uncertainty caused by the pandemic's novelty and the lack of understanding about the duration of lockdowns causes panic buying vital products, even those with long shelf lives. Given the inelastic character of food consumption, this significant increase in demand has ramifications for food prices (Emediegwu and Nnadozie, 2023). Covid-19 has also caused many informal workers to lose their jobs, have no income, and cannot purchase food (Varma and Sutradhar, 2023). Concerns have also been raised about the quality of jobs that have emerged post-pandemic, with many moving from formal to informal businesses (Varma and Sutradhar, 2023).

Hypothesis 4: food prices will rise due to new Covid-19 cases.

The war in Ukraine was the primary cause of food price inflation, reaching all-time highs in 2022. On the one hand, Russia and Ukraine have traditionally been major global suppliers of wheat, barley, and sunflower oil. Russia also accounts for 23%, 21%, 14%, and 10% of global ammonia, potash, urea, and processed phosphate exports, respectively (Feng et al., 2023). On the other hand, the start of the Russia-Ukraine war hampered trade in energy (fuel) and fertilizer (and its raw materials). The lack of fertilizer supply in global markets causes prices to rise, and some farmers may choose to use less of this input, which lowers agricultural yield (Zhou and Chen, 2023).

Hypothesis 5: food prices will rise due to the Russia-Ukraine war.

Monetary policy has also had a positive effect on food prices. When monetary policy is restrictive, rising food prices in the country are destabilized even further. The disruption is apparent in the distribution of food prices (Iddrisu and Alagidede, 2020). Previous studies have found that a country's real exchange rate and money supply impact inflation. An increase in interest rates will decrease the value of inflation (Egilsson, 2020). Furthermore, consumer confidence might have an impact on inflation. Consumer confidence or an optimistic consumer mindset will cause inflation to rise (Kilci, 2020).

Hypothesis 6: food prices will rise due to increases in the real exchange rate.

Hypothesis 7: food prices will decrease due to increases in interest rates.

Hypothesis 8: food prices will rise due to increases in the consumer confidence index.

3. Material and Methods Results

3.1. Data source

This study employs monthly time series data. The secondary data was collected from July 2012 - December 2022 (126 data observations). The sample country in this study is Indonesia. Several variables will be analyzed in this study (Table 1). The first variable is the food consumer prices index, which is the dependent variable. These indices measure the price change between the current and reference periods of the average basket of foods purchased by households. Eight explanatory variables are thought to influence the food consumer prices index. First is the global price of food index. This price reflects a benchmark for the global food market, as determined by the top exporters. Second is the global price of energy index. This price reflects a benchmark for the global energy market, as determined by the top exporters. Third is temperature change; the FAOSTAT temperature change on the land domain disseminates annual updates of mean surface temperature change statistics by country. Fourth, new Covid-19 case; The most recent public health case of Covid-19 in humans induced by SARS-COV-2 infection is utilized to define this variable. Fifth, the Russia-Ukraine war refers to the series of armed clashes between Russia and Ukraine. Sixth, real broad effective exchange rate; Real effective exchange rates are calculated as weighted averages of bilateral exchange rates adjusted for relative consumer prices. Seventh, interest central bank rates; This variable displays the bank loan interest rate determined by each country's central bank. Eighth, the consumer confidence index; This indicator forecasts future changes in household consumption and savings based on responses to questions about their expected financial situation, overall economic attitude, unemployment, and ability to save.

Table 1. Variable in This Study

Variable	Symbol	Source
Food consumer prices indices (2015 = 100)	FPI	FAO
Global price of food index (Index 2016 = 100)	GFI	Federal Reserve Bank of St. Louis
Global price of energy index (Index 2016 = 100)	GEI	Federal Reserve Bank of St. Louis
Temperature change (°c)	TEMP	FAO
Covid-19 new case (person)	COV	WHO
Russia-Ukraine conflict	RUW	The Armed Conflict Location & Event Data Project
Real broad effective exchange rate (Index 2020=100)	RER	Federal Reserve Bank of St. Louis
Interest central bank rates (%)	INT	Federal Reserve Bank of St. Louis
Consumer confidence index	CCI	OECD

3.2. Data analysis

The impact of global economic uncertainty, climate change, Covid-19 or the Russia-Ukraine war on food prices in Indonesia (i) every year (t) will be assessed using the model:

$$FPI_{it} = \beta_0 + \beta_1 GFI_{it} + \beta_2 GEI_{it} + \beta_3 TEMP_{it} + \beta_4 COV_{it} + \beta_5 RUW_{it} + \beta_6 RER_{it} + \beta_7 INT_{it} + \beta_8 CCI_{it} + \varepsilon_i \quad (1)$$

The empirical analysis begins with the Augmented Dicky Fuller (ADF) unit root test before the estimation. The stationarity test was performed to eliminate spurious regression caused using nonstationary time-series data throughout the period. The data is said to be stationary if it meets the criteria: the mean and variance are constant over time and the covariance between two time series data only depends on the lag between the two time periods.

$$\Delta Y_{it} = \alpha Y_{it-1} + \sum \beta_{it} \Delta Y_{it} - j + X_{it}\delta + v_{it} \quad (2)$$

Y_{it} is the pooled variable, X_{it} is an exogenous variable, v_{it} is the error term.

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 (Shrestha, Bhatta, 2018):

$$Y_t = A_1 Y_{t-1} + \varepsilon_t, \quad (3)$$

so that

$$\Delta Y_t = A_1 Y_{t-1} - Y_{t-1} + \varepsilon_t \quad (4)$$

$$= (A_1 - I)\, Y_{t-1} + \varepsilon_t \text{ can be written as} \quad (5)$$

$$= \Pi Y_{t-1} + \varepsilon_t \quad (6)$$

Y_t and ε_t are (n.1) 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 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. These differences necessitate adjustments to correct for disequilibrium, which are known as error correction models (ECM):

$$EG_t = FPI_{it} - \beta_0 - \beta_1 GFI_{it} - \beta_2 GEI_{it} - \beta_3 TEMP_{it} - \beta_4 COV_{it} - \beta_5 RUW_{it} - \beta_6 RER_{it} - \beta_7 INT_{it} - \beta_8 CCI_{it} \quad (7)$$

EG_t is a disequilibrium error.

The dependent and explanatory variables are rarely in equilibrium, so it is necessary to observe the disequilibrium relationship:

$$FPI_{it} - FPI_{it-1} = b_0 + b_1 GFI_{it} + b_2 GFI_{it-1} + b_3 GEI_{it} + b_4 GEI_{it-1} + b_5 TEMP_{it} + b_6 TEMP_{it-1} + b_7 COV_{it} + b_8 COV_{it-1} + b_9 RUW_{it} + b_{10} RUW_{it-1} + b_{11} RER_{it} + b_{12} RER_{it-1} + b_{13} INT_{it} + b_{14} INT_{it-1} + b_{15} CCI_{it} + b_{16} CCI_{it-1} - (1 - \Phi) FPI_{it-1} + e_t \quad (8)$$

Adding and subtracting with $a_n X_{t-1}$ on the right side of equation (8) gives:

$$FPI_{it} - FPI_{it-1} = b_0 + b_1 GFI_{it} - b_1 GFI_{it-1} + b_1 GFI_{it-1} + b_2 GFI_{it-1} + b_3 GEI_{it} - b_3 GEI_{it-1} + b_3 GEI_{it-1} + b_4 GEI_{it-1} + b_5 TEMP_{it} - b_5 TEMP_{it-1} + b_5 TEMP_{it-1} + b_6 TEMP_{it-1} + b_7 COV_{it} - b_7 COV_{it-1} + b_7 COV_{it-1} + b_8 COV_{it-1} + b_9 RUW_{it} - b_9 RUW_{it-1} + b_9 RUW_{it-1} + b_{10} RUW_{it-1} + b_{11} RER_{it} - b_{11} RER_{it-1} + b_{11} RER_{it-1} + b_{12} RER_{it-1} + b_{13} INT_{it} - b_{13} INT_{it-1} + b_{13} INT_{it-1} + b_{14} INT_{it-1} + b_{15} CCI_{it} - b_{15} CCI_{it-1} + b_{15} CCI_{it-1} + b_{16} CCI_{it-1} - (1 - \Phi) FPI_{it-1} + e_t \quad (9)$$

Equation (9) also can be written:

$$\Delta FPI_{it} = b_0 + b_1 \Delta GFI_{it} + (b_1 + b_2) GFI_{it-1} + b_3 \Delta GEI_{it} + (b_3 + b_4) GEI_{it-1} + b_5 \Delta TEMP_{it} + (b_5 + b_6) TEMP_{it-1} + b_7 \Delta COV_{it} + (b_7 + b_8) COV_{it-1} + b_9 \Delta RUW_{it} + (b_9 + b_{10}) RUW_{it-1} + b_{11} \Delta RER_{it} + (b_{11} + b_{12}) RER_{it-1} + b_{13} \Delta INT_{it} + (b_{13} + b_{14}) INT_{it-1} + b_{15} \Delta CCI_{it} + (b_{15} + b_{16}) CCI_{it-1} - \lambda FPI_{it-1} + e_t \quad (10)$$

Δ = first difference and $\lambda = 1 - \Phi$

4. Results

Indonesia's average food consumer price index (FPI) was 108.91 (see Table 2). FPI in Indonesia exhibits significant variations, with a standard deviation value of 13.41% of the average. Indonesia's average temperature (TEMP) increase is approximately 1.04 ºC, with a standard deviation of 0.30 ºC. Indonesia's standard deviation of new Covid-19 cases (COV) is 3.29 times the average. This is understandable because this pandemic took quite a long time to handle. Meanwhile, three other variables reflecting shocks in this study, the global price of energy index (GEI), the global price of food index (GFI), and the Russia-Ukraine war (RUW), were obtained from the global level so that the mean and standard deviation will be the same across countries. Three other variables in this study indicate a country's domestic economic conditions: the consumer confidence index (CCI), interest central bank rates (INT), and the real broad effective exchange rate (RER). Indonesia's average CCI was 100.72, with INT and RER averages of 5.47 and 106.80, respectively.

Table 2. Descriptive Statistics

Variable	**Indonesia**	
	Mean	**Std. deviation**
FPI	108.91	14.60
GFI	112.50	16.12
GEI	166.83	66.17
TEMP	1.04	0.30
COV	53331.90	175328.42
RUW	70.60	193.49
RER	106.80	8.74
INT	5.47	1.41
CCI	100.72	0.86

Source: Secondary data analysis

Unit root analysis results show variables' variations (Table 3). Only TEMP is stationary at the level in this study. FPI, GFI, COV, RER, INT, and CCI are significant at the 1st difference, while GEI and RUW are significant at the 2nd difference. As a result, the entire variable will be analyzed at the 2nd difference level.

Table 3. ADF Unit Root Test

Variable	**Indonesia**	
	Level	**Sig.**
FPI	1st difference	-8.218***
GFI	1st difference	-7.099***
GEI	2nd difference	-13.181***
TEMP	At level	-4.447***
COV	1st difference	-10.991***
RUW	2nd difference	-2.958**
RER	1st difference	-9.131***
INT	1st difference	-6.430***
CCI	1st difference	-4.545***

sig 0.000: ***, sig 0.01: **

Source: Secondary data analysis

The cointegration test results show that variables in all models have a long-run relationship (Table 4). This means that the FPI, GFI, GEI, TEMP, COV, RUW, RER, INT, and CCI variables are cointegrated. It is indicated that the trace statistics value is higher than the critical value at the 5% confidence level.

Table 4. Cointegration Test of the Model

Hypothesized No. of CE (s)	INA
None	308.554***
At most 1	215.601***
At most 2	155.370***
At most 3	102.766**

sig 0.000: ***, sig 0.01: **

Source: Secondary data analysis

The ECM analysis of the determinant factors of FPI in Indonesia is considered valid because the RESID probability is less than 0.05 (see Table 5). The RESID indicates that the previous month's error term was corrected for within the current month at a convergence speed of 0.1421. The CCI causes FPI increases in the long run (0.9275) but has no significant impact in the short run. The same condition remains for the explanatory variables GFI, TEMP, COV, and RUW, which increase FPI by 0.1868, 4.9287, 0.000001, and 0.0298 in the long run and have no significant impact in the short run. INT, RER, and GEI have no short-run influence on FPI; nevertheless, each variable can reduce it in the long run (INT: -3.6309, RER: -0.8572, and GEI: -0.0479).

Table 5. Determinant Factors of the Indonesian Food Price in the Short-run and Long-run

Variable	Short-run		Variable	Long-run	
	coef.	std. error		coef.	std. error
D(GFI)	0.0049	0.0470	GFI	0.1868**	0.0672
	(0.1053)			(2.7813)	
D(GEI)	-0.0077	0.0076	GEI	-0.0479**	0.0147
	(-1.0145)			(-3.2679)	
D(TEMP)	0.3290	0.5391	TEMP	4.9287***	1.3484
	(0.6102)			(3.6552)	
D(COV)	-0.00000001	0.0000001	COV	0.000001*	0.0000004
	(-0.1141)			(2.2809)	
D(RUW)	0.0002	0.0014	RUW	0.0298***	0.0031
	(0.1228)			(9.7382)	
D(RER)	0.0176	0.0590	RER	-0.8572***	0.0512
	(0.2989)			(-16.7519)	
D(INT)	0.5975	0.5516	INT	-3.6309***	0.3131
	(1.0832)			(-11.5970)	
D(CCI)	-0.2972	0.5343	CCI	0.9275 .	0.4804
	(-0.5563)			(1.904)	
RESID(-2)	-0.1421***	0.03343		-	-
	(-4.2504)				
C	0.4275***	0.112	C	119.5796*	50.0359
	(3.8442)			(2.3999)	
Adj. R squared		0.1715	Adj. R squared		0.9349
F-statistic		2.6227**	F-statistic		225.3065***

sig 0.000: ***, sig 0.01: **, sig 0.05:*, sig 0.1

Source: Secondary data analysis

5. Discussion

5.1. Impact of global economic uncertainty, climate change, Covid-19 or the Russia-Ukraine war on food prices in Indonesia

The relationship between global food prices (GFI) and food prices (FPI) in a country is related to trade liberalization. This process is related to tariff reductions and price increases. Increased trade openness influences the level of price transmission. Deeper market integration raises FPI during GFI spikes (Flachsbarth and Garrido,

2014). The rise in GFI will encourage many countries to export food, causing the domestic food supply to decline and FPI to rise. For example, Indonesia is the primary palm oil producer in the global market and exports it to other countries. However, it has a harmful effect, causing the cooking oil supply to decrease and its price to increase. An increase in GFI will also force a country to pay more for imported food and increase FPI. However, a spike in GFI will make countries concerned, causing them to strive to increase food production while preventing these supplies from being exported (export ban), as India has done (Tian and Lin, 2023). This situation is crucial for Indonesia to scale up agricultural production and impose an export ban to withstand rising domestic food prices (Food and Agriculture Organization of the United Nations, 2024).

Climate change (TEMP) has raised FPI in Indonesia. The stages of the agri-food value chain (e.g., growing, harvesting, and storing crops, raising livestock, and storing and transporting animal products) in Indonesia are sensitive to TEMP, which affects the costs, supply, and pricing of almost all agricultural products. These issues contributed to the overall market sentiment and increased FPI (Zhou and Chen, 2023). Biodiversity destruction in Indonesia is severe, particularly in the agricultural sector. The severity of water scarcity has also worsened in recent decades. As a result, agricultural production fluctuates dramatically depending on the season (Nematchoua et al., 2020).

The same phenomenon also occurs in China. Extreme drought events significantly reduced agricultural production in China between 1000 and 2000 AD, causing severe food shortages and famine, resulting in rising food prices and inflation, and ultimately causing financial risks and social upheaval in the dynasties (Fan et al., 2022).

One solution to reduce climate change, greenhouse emissions, and CO_2 is using renewable energy (Harvey and Pilgrim, 2011). Renewable energy is a key factor for developing countries' economic growth without damaging the environment. The use of renewable energy in developing countries has been proven to reduce the harmful effects of climate change without increasing food prices. In addition, renewable energy production's efficiency in Indonesia is important to minimize the negative impact of climate change on the economy, society, and future development (Nugroho et al., 2024).

The Indonesian government-imposed travel restrictions and lockdown policies to reduce the number of Covid-19 infections. Lockdowns will reduce food availability and lead to farm labor shortages. This policy was also accompanied by disruptions in transportation, logistics networks, and exports, making agricultural inputs such as seeds, fertilizers, and pesticides challenging to get throughout the pandemic. Transportation barriers caused by Covid-19 induced restrictions may prohibit farmers from reaching their farms or result in the waste of harvested farm produce because it cannot reach the final consumers. This imbalance between demand and supply generates food scarcity, which affects food prices (Emediegwu and Nnadozie, 2023). In addition, reduced fertilizer output and exports from producing countries cause chaos in the supply of chemical fertilizers and cereal crops in the main agricultural-producing countries. Farmers' desire to adopt new technologies and sound agricultural practices has decreased under Covid-19, impeding sustainable agricultural growth (Zhou and Chen, 2023).

Major producing countries have also imposed export bans in response to the Covid-19 outbreak. This limitation raises the price of international products. For example, in 2020-2021, India bought 14.55 million tons of edible oil for US$ 9.5 billion. Despite an 8% decline in total imports over the previous year, the value of India's edible oil imports in 2020-2021 (during the Covid-19 epidemic) climbed by 15% due to price rises (Valiyaveettil et al., 2023). The export ban is still worsened by market sentiment variables, such as consumer panic buying and importers hoarding to enhance domestic production (Zhou & Chen, 2023).

FPI has risen in Indonesia because Russia conflicts with Ukraine (RUW). This makes sense given the country's reliance on food imports from Russia and Ukraine. Indonesia is Ukraine's second-largest importer of wheat (Nasir et al., 2022). The same case happened in India, its edible oil imports in 2021-2022 (during the Russia-Ukraine crisis) climbed by 5.4%, but the value of imports increased by 71% over the previous year. The import bill nearly quadrupled from 2019-20 to 2021-2022 for the same level of imports, indicating more expensive imports. After 2019-2020, the unit value of all edible oil imports increased sharply (Valiyaveettil et al., 2023).

In addition, Russia and Ukraine have an important role in global trade, particularly in food, fertilizer, and fuel. The war has prohibited Ukraine from producing and exporting food products. Many countries have banned the import of Russian products. As a result, global food supplies are decreasing, posing a threat to Russian and Ukrainian food importers. Agricultural input is likewise limited, therefore the rise in fertilizer prices (e.g., nitrogen and phosphates) increased agricultural production costs and food prices (Zhou & Chen, 2023). The most challenging obstacle is that the RUW remains unfinished and lacks a solution. The impact is felt where the increase in FPI lasts long term.

The increase in global energy prices (GEI) reduced FPI in Indonesia. Indonesia is an energy producer and will be used when the GEI rises. Hence, domestic energy prices will remain stable, and the impact will not affect the FPI (Nematchoua et al., 2020). Furthermore, the Indonesian government gives subsidies for domestic fuel, keeping prices stable despite the increase in GEI. Arintoko et al. (2024) also stated that Indonesian energy subsidies allow increases in international energy prices without increasing the CPI significantly.

Aside from that, Indonesia is currently beginning to use renewable energy as fuel, especially the B20 policy, which refers to a fuel mixture consisting of 20% vegetable oil and 80% petroleum. The government has established a policy for using palm oil in gasoline mixtures (Harvey and Pilgrim, 2011). Renewable energy can help to minimize the expenses of sending agricultural products from rural farmers to urban consumers (Hassan, 2022). This means that increasing GEI has little influence on increasing FPI

5.2. Impact of other variables on food prices in Indonesia

Filip et al. (2019) claimed that the RER could influence the increase or decrease of FPI. However, this direction is mainly determined by the global food market dynamics. There is tremendous integration between Indonesia and international agricultural commodity markets (Flexor et al., 2023). Global food prices will affect domestic food conditions in Indonesia during a food crisis. When the food crisis is over, the exchange rate becomes the most important element to manage food prices (Filip et al., 2019).

The interest rate (INT) is the cause of the FPI decline in Indonesia. Monetary policies, especially INT, appear to be an appropriate approach to stabilizing food prices and ensuring food availability for people experiencing poverty in Indonesia (Flachsbarth and Garrido, 2014). A rise in INT reduces the amount of money circulating in a country. When the money supply is reduced, the value of that money increases (appreciation), and food price decreases. For example, a 1% fall in China's money supply reduces the price of wheat flour by 0.2%. Wheat production in China has so far been unable to meet market demands due to limited land area and seasonal factors. Hence, the Chinese government will import wheat to fulfill domestic demand. When the currency appreciates, the price of imported wheat falls, and it is sold at a low price on the domestic market (Yu, 2014). Meanwhile, there is also the possibility that an increase in saving or borrowing INT leads to a reduction in investment demand for agricultural products. As a result, agricultural production will decrease and food prices will rise (Wagan et al., 2018).

Consumer confidence (CCI) has increased FPI in Indonesia. Indonesian consumers' optimism about the economic situation has encouraged them to consume more food, leading to a rise in the FPI. Demand for higher-

value foods such as meats, dairy products, and aquatic items is also increasing rapidly. Supply frequently falls short of meeting demand, resulting in excessive food price inflation (Gandhi & Zhou, 2014).

Based on the analysis results in Table 5, not all our hypotheses have been proven. The following hypotheses have been supported: 2, 5, 7, and 8. Meanwhile, the following hypotheses are unsupported: 1, 2, 4, and 6 (Table 6).

Table 6. Supported or Unsupported the Hypothesis of This Study

Hypotheses	Note
Hypothesis 1: food prices will rise due to increases in global food prices.	Supported
Hypothesis 2: food prices will rise due to increases in global energy prices.	Unsupported
Hypothesis 3: food prices will rise due to climate change.	Supported
Hypothesis 4: food prices will rise due to Covid-19 new cases.	Supported
Hypothesis 5: food prices will rise due to the Russia-Ukraine conflict.	Supported
Hypothesis 6: food prices will rise due to increases in the real exchange rate.	Unsupported
Hypothesis 7: food prices will decrease due to increases in interest rates.	Supported
Hypothesis 8: food prices will rise due to increases in the consumer confidence index.	Supported

6. Conclusion

Global food prices, climate change, Covid-19, the Russia-Ukraine war, and consumer confidence all raise food prices in the long run, while global energy prices, interest central bank rates, and real broad effective exchange rates have the reverse impact. According to the analysis, climate change has the worst effect on food prices in Indonesia. Based on the findings of this study, we make the following essential recommendations for managing domestic food prices: 1) increase food production and efficiency in Indonesia to mitigate the adverse effects of global shocks and climate change. This can be accomplished by increasing agricultural smart technology and enhancing the food supply chain. In addition, the Indonesian government must impose incentive policies to increase food production and efficiency, such as reasonable prices, agricultural machinery support, production factor subsidy, etc.; 2) encourage Indonesia to expand renewable energy production and usage. This step is intended to lessen reliance on global energy price swings and mitigate climate change. The Indonesian government must continue and expand bio solar (B-40) policy and other; 3) maintain domestic economic stability by implementing fiscal and monetary policies according to Indonesian circumstances and capabilities; and 4) enhance international cooperation in dealing with global issues, particularly disease outbreaks, and reducing the creation of global conflicts. Indonesia must conduct its free international policy without taking sides in one country or a group of countries. Indonesia must also participate in the United Nations activities or forums to reduce global conflict.

The primary limitation of this study is that it does not account for a country's social, political, and security issues. Indonesian domestic conditions change quickly, which can probably change the article's findings. Some studies have proved that social, political, and security problems harm food security and price. As a result, we propose future research that includes Indonesian social, political, and security stability indexes from Worldwide Governance Indicators.

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7. References

1. Arintoko A, Kadarwati N, Badriah LS (2024): The asymmetric effects of global energy and food prices, Exchange rate dynamics, and monetary policy conduct on inflation in Indonesia. Ekonomika 103, 66–89. 10.15388/Ekon.2024.103.2.4.
2. Bandara JS, Cai Y (2014): The impact of climate change on food crop productivity, food prices and food security in South Asia. Economic Analysis and Policy 44, 451–465. https://doi.org/10.1016/j.eap.2014.09.005
3. Cariappa AA, Acharya KK, Adhav CA, R S, Ramasundaram P, Kumar A, Singh S, Singh GP (2022): COVID-19 induced lockdown effect on wheat supply chain and prices in India – Insights from state interventions led resilience. Socio-Economic Planning Sciences 84, 101366. https://doi.org/10.1016/j.seps.2022.101366
4. Chang BH, Gohar R, Derindag OF, Uche E (2022): COVID-19, lockdown measures and their impact on food and healthcare prices: empirical evidence using a dynamic ARDL model. Journal of Economic Studies 2019, 1–19. https://doi.org/10.1108/JES-12-2021-0627
5. Delince J, Ciaian P, Witzke HP (2015): Economic impacts of climate change on agriculture: The AgMIP approach Jacques. Journal of Applied Remote Sensing 9, 1–17. https://doi.org/10.1093/jae/eju011
6. Drysdale RE, Bob U, Moshabela M (2021): Socio-economic determinants of increasing household food insecurity during and after a drought in the District of iLembe, South Africa. Ecology of Food and Nutrition 60, 25–43. https://doi.org/10.1080/03670244.2020.1783663
7. Egilsson JH (2020): How raising interest rates can cause inflation and currency depreciation. Journal of Applied Economics 23, 450–468. https://doi.org/10.1080/15140326.2020.1795526
8. Emediegwu LE, Nnadozie OO (2023): On the effects of COVID-19 on food prices in India: A time-varying approach. European Review of Agricultural Economics 50, 232–249. https://doi.org/10.1093/erae/jbac015
9. Fan J, Jiang H, Xu H, Zhang W (2022): Impacts of seismic activity and climatic change on Chinese history in the recent millennium. Journal of Geographical Sciences 32, 2328–2348. https://doi.org/10.1007/s11442-022-2050-1
10. Feng F, Jia N, Lin F (2023): Quantifying the impact of Russia–Ukraine crisis on food security and trade pattern: evidence from a structural general equilibrium trade model. China Agricultural Economic Review 15, 241–258. https://doi.org/10.1108/CAER-07-2022-0156
11. Filip O, Janda K, Kristoufek L, Zilberman D (2019): Food versus fuel: An updated and expanded evidence. Energy Economics 82, 152–166. https://doi.org/10.1016/j.eneco.2017.10.033
12. Flachsbarth I, Garrido A (2014): The effects of agricultural trade openness on food price transmission in Latin American countries. Spanish Journal of Agricultural Research 12, 927–940. https://doi.org/10.5424/sjar/2014124-6292
13. Flexor G, Kato KY, Leite SP (2023): Agri-food globalization and food security in Brazil: Recent trends and contradictions. Journal of Peasant Studies 4, 1022-1045. https://doi.org/10.1080/03066150.2023.2259807
14. Food and Agriculture Organization of the United Nations (2024): FAOSTAT. https://www.fao.org/faostat/en/#data (accessed: 28/10/2024).
15. Gandhi VP, Zhou Z (2014): Food demand and the food security challenge with rapid economic growth in the emerging economies of India and China. Food Research International 63, 108–124. https://doi.org/10.1016/j.foodres.2014.03.015
16. Harvey M, Pilgrim S (2011): The new competition for land: Food, energy, and climate change. Food Policy 36, S40–S51. https://doi.org/10.1016/j.foodpol.2010.11.009
17. Hassan FA (2022): Dynamic shocks of crude oil price and exchange rate on food prices in emerging countries of Southeast Asia: A panel vector autoregression model. Asian Journal of Economic Modelling 10, 108–123. https://doi.org/10.55493/5009.v10i2.4517
18. Humphrey TM (1998): Historical origins of the cost-push fallacy. Federal Reserve Bank of Richmond Economic Quarterly 84, 53–74.
19. Iddrisu AA, Alagidede IP (2020): Monetary policy and food inflation in South Africa: A quantile regression analysis. Food Policy 91, 1–13. https://doi.org/10.1016/j.foodpol.2019.101816
20. Iliyasu J, Mamman SO, Ahmed UA (2023): Impact of climate change on output and inflation in Africa's largest economies. Climate and Development 1–12. https://doi.org/10.1080/17565529.2023.2172315
21. Im KS, Pesaran MH, Shin Y (2003): Testing for unit roots in heterogeneous panels. Journal of Econometrics 115, 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

22. Kilci EN (2020): Do confidence indicators have an impact on macro-financial indicators? An analysis of the financial service and real sector confidence indexes: Evidence from Turkey. European Journal of Government and Economics 9, 74–94. https://doi.org/10.17979/ejge.2020.9.1.5948
23. Kraus S, Clauss T, Breier M, Gast J, Zardini A, Tiberius V (2020): The economics of COVID-19: initial empirical evidence on how family firms in five European countries cope with the corona crisis. International Journal of Entrepreneurial Behaviour and Research 26, 1067–1092. https://doi.org/10.1108/IJEBR-04-2020-0214
24. Mhonyera G, Masunda S, Meyer DF (2023): Measuring the pass-through effect of global food price volatility and South Africa's CPI on the headline inflation of Zimbabwe. Cogent Food & Agriculture 9, 1–15. https://doi.org/10.1080/23311932.2023.2212458
25. Nasir MA, Nugroho AD, Lakner Z (2022): Impact of the Russian–Ukrainian Conflict on Global Food Crops. Foods 11, 1–16. https://doi.org/10.3390/foods11192979
26. Negi DS (2022): Global food price surge, in-kind transfers and household welfare : Evidence from India. World Development 158, 106009. https://doi.org/10.1016/j.worlddev.2022.106009
27. Nematchoua MK, Asadi S, Reiter S (2020): Influence of energy mix on the life cycle of an eco-neighborhood, a case study of 150 countries. Renewable Energy 162, 81–97. https://doi.org/10.1016/j.renene.2020.07.141
28. Neves MF (2010): The food business environment and the role of China and Brazil building a 'food bridge'. China Agricultural Economic Review 2, 25–35. https://doi.org/10.1108/17561371011017478
29. Nugroho AD, Fekete-Farkas M, Lakner Z (2024): Impact of climate change mitigation actions on food prices in developing countries. Regional Statistics 14, 1025–1049. 10.15196/RS140601.
30. Schwarzer JA (2018): Retrospectives: Cost-push and demand-pull inflation: Milton friedman and the 'Cruel dilemma'. Journal of Economic Perspectives 32, 195–210. 10.1257/jep.32.1.195.
31. Shrestha MB, Bhatta GR (2018): Selecting appropriate methodological framework for time series data analysis. Journal of Finance and Data Science 4, 71–89. https://doi.org/10.1016/j.jfds.2017.11.001
32. Tian X, Lin F (2023): Trade liberalization and nutrition transition: Evidence from China. Economics and Human Biology 51, 101304. https://doi.org/10.1016/j.ehb.2023.101304
33. Valiyaveettil RR, Jha GK, Kathayat B (2023): Pushing for self-sufficiency in edible oils in India in the aftermath of recent global events. National Academy Science Letters 46, 483–486. https://doi.org/10.1007/s40009-023-01294-z
34. Varma S, Sutradhar R (2023): Food and communities in post-COVID-19 cities: Case of India. Urban Governance 3, 97–105. https://doi.org/10.1016/j.ugj.2023.03.002
35. Wagan ZA, Chen Z, Seelro H, Shah MS (2018): Assessing the effect of monetary policy on agricultural growth and food prices. Agricultural Economics (Czech Republic) 64, 499–507. 10.17221/295/2017-AGRICECON.
36. Wang Y, Zhao S, Yang Z, Liu DJ (2015): Food versus crude oil: What do prices tell us? Evidence from China. China Agricultural Economic Review 7, 435–447. https://doi.org/10.1108/CAER-09-2014-0091
37. Widarjono A, Susantun I, Ruchba SM, Rudatin A (2020): Oil and food prices for a net oil importing-country: How are related in indonesia? International Journal of Energy Economics and Policy 10, 255–263. 10.32479/ijeep.9557.
38. Yu X (2014): Monetary easing policy and long-run food prices: Evidence from China. Economic Modelling 40, 175–183. https://doi.org/10.1016/j.econmod.2014.03.029
39. Zhou Y, Chen KZ (2023): Food Price Inflation in East and Southeast Asia: Situation, Driving Forces, and the Outlook. Studies in Agricultural Economics 125, 77–86. https://doi.org/10.7896/j.2556