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OIL AND FOOD PRICE BEFORE AND DURING COVID-19 PANDEMIC IN NIGERIA: A NON-LINEAR ARDL APPROACH

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Abstract: This paper analyzes the relationship between food and oil prices in Nigeria before and during the COVID-19 pandemic, using monthly data from January 2018 to December 2021. The ARDL and NARDL models are applied to estimate the symmetry and asymmetric relationship that exists in food price behavior. The NARDL confirms the presence of asymmetries, and the bound test affirms the co-integration and long-run relationship among the variables. In the long run, there is a significant positive relation between oil price increases and food prices, but the long-run impact of oil price reductions on food prices is not significant. In the short run, only increases in oil prices exert a significant influence on food prices, while decreases in oil prices do not. Furthermore, the COVID-19 period exerts a positive and significant impact on food prices, while COVID-19 cases do not influence food prices in Nigeria.

Keywords: Food price; Food price behaviour; Oil price; Asymmetry; ARDL; NARDL; Nigeria.

JEL Codes: D12, L66, O13.

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1. Introduction

Food is essential for the sustenance of all living organisms. It provides vital nutrients and sustains growth and well-being. The prices of food and their fluctuations have a significant impact on the livelihoods of individuals and the overall economy. The rise in food prices, coupled with fluctuating oil prices, has had a profound effect on the Nigerian economy, particularly during the COVID-19 pandemic. This research aims to identify the relationship between oil and food prices, especially during the pandemic, to assist policymakers in understanding and addressing these issues.

The Nigerian Government is aware of the implications of rising food prices, particularly in relation to the fluctuation of oil prices, which are crucial to the country's economy. Policymakers, labor unions, and civil society organizations believe that the rising oil prices have contributed to the increase in food prices and the devaluation of the Nigerian currency.

Nigeria's economy heavily relies on crude oil, and changes in oil prices significantly impact the country's prosperity and economic progress. Oil is used to power machines, transport inputs like fertilizer and pesticides, and deliver finished goods to consumers. Consequently, these activities become more costly when oil prices rise. Increased oil prices can lead to economic inflation, higher input and transportation costs, and a decline in investment (Interagency Agency, 2011).

The recent decision by the Nigerian government to remove petrol subsidies and the subsequent resistance from labor unions and civil society organizations further highlights the impact of oil prices on other macroeconomic variables, particularly food prices. The labor unions argue that further increases in oil prices will only result in skyrocketing commodity prices without a proportional increase in wages, leading to currency devaluation and increased inflation.

Various factors, such as extreme weather events, policy shocks, demand shocks, monetary issues, and energy prices, including oil prices, have been linked to fluctuations in food prices in recent years (Tadesse et al., 2016). Energy costs have been identified as the primary factor influencing global agricultural prices (Fowowe, 2016; Pal & Mitra, 2017, 2018). Abbott et al. (2008, 2009) identified energy costs, the value of the US dollar, and excess demand as the major drivers of rising food prices in the global market.

While food price hikes are not new in Nigerian markets, the current situation is concerning due to the increase in prices across all food and feed commodities, not just specific crops (FAO, 2016). Despite efforts to increase agricultural productivity, including government interventions, the rise in food prices contradicts these initiatives and can lead to higher inflation. Changes in food prices create uncertainty for households.

This paper aims to contribute to the existing research by investigating the relationship between oil and food price inflation, the impact of the COVID-19 pandemic on food price inflation, and the influence of oil prices on food prices from a Nigerian perspective. By addressing these topics, this study will provide valuable insights for researchers and policymakers. Previous studies have overlooked the examination of the relationship between oil prices and food prices in the context of COVID-19, as well as the impact of transmission mechanisms such as exchange rates, monetary policy rates, and narrow money on food prices in Nigeria. This study intends to fill this research gap by exploring these variables and their effects on food prices in Nigeria.

Furthermore, existing studies have not thoroughly investigated the impact of the COVID-19 period on food price inflation, nor have they addressed the issue of using inappropriate methodologies. This study aims to address these gaps in the literature and contribute to a more comprehensive understanding of the subject. Additionally, this research will expand on previous studies by examining the influence of additional macroeconomic variables, including exchange rates, monetary policy rates, and narrow money, on the food price index in Nigeria. This analysis will offer new insights and contribute to the existing body of knowledge on the topic.

2. Literature review

Any material consumed as food provides nutrition for an organism. These behaviors usually developed to fill a specific ecological niche in certain geographic areas. Currently, the industrial food sector is responsible for producing most of the food required to feed the world's continuously expanding population. This sector utilizes intensive farming techniques to produce food and then distributes it through complex food processing and distribution networks. However, traditional agriculture depends heavily on fossil fuels, which are responsible for up to 37% of global greenhouse gas emissions. As a result, the food and agriculture system has become one of the primary drivers of climate change (SAPEA, 2020).

Food and nutrition security has returned to the world development agenda as a result of the spike in food prices that sparked protests in numerous nations in 2008. Because they rely mostly on market purchases and food purchases make up the majority of their spending, poor urban residents are sensitive to changes in food costs. The threat of growing food prices has become increasingly concerning over the years in Nigeria, which raises the question of what is genuinely to blame for the sharp increase in the most vital good for human survival in a nation blessed with arable land for food production.

There have been a series of postulations as regards the relationship that subsists between food price inflation and oil prices most especially in Nigeria. This is because there has always been an increase in general price level most especially food price inflation in response to increase in oil prices. This may be due to the menace of our inability to produce what we consume and dwindling foreign exchange as a result of the rising cost of refining petroleum products leading to the high cost of oil.

Demand-pull inflation, cost-push inflation, structural inflation, and imported inflation are a few of the hypotheses that have been employed to explain inflation globally. A sort of inflation known as "demand pull" occurs when the total demand for commodities in an economy exceeds the total supply, or when there are too many people vying for a limited number of items. Moreover, it is known as surplus demand (Totonchi, 2011). The supply side is where the Cost-Push Theories of Inflation originate. Inflation is mostly brought on by growing manufacturing costs, which raise the price of goods and services. It is also known as "inflation of market power." One type of inflation known as structural inflation is connected to the process of economic growth. It is thought that the disequilibrium that results from economic development in a developing nation causes inflation, which is not driven by cost-push inflation or demand-pull inflation but rather by sectorial changes in demand. Countries that completely rely on imported products and services, like Nigeria, are known for having imported inflation. Imported inflation results from products being dumped in the country of importation; these goods may take the shape of inputs or finished goods. Inflation increases as a result of the high cost of importing such commodities into the local economy (Gbanador, 2007).

Several empirical studies have been conducted to investigate the impact of oil price changes on the increase in food price inflation over the years in both developed and developing countries, including those that export and import oil. The majority of these studies have found a link between oil prices and food prices. Between 2014 to 2016 when the global oil price fell from $102.33 to $30.66, global food prices also follow the same decreasing pattern and while there is an increase from $30.66 to $75 by December 2021, there have been a relative increase in food prices in most countries and most especially Nigeria.

In order to find empirical evidence for or against the complete elimination of petroleum pump price subsidies, Babalola and Salau (2020) looked into the relationship between Nigeria's consumer pricing index (CPI) and petroleum pump price (PPP). Petroleum Pump Price was represented by the prices of gasoline, diesel, and kerosene at the pump. Manufacturing, transportation, food, and domestic activities were the four segments of the economy. In their study, they came to the conclusion that, in the short term, gasoline pump prices have a significant impact on food price inflation. The impact is direct and expected, but the relationship is negative in the long term.

Ibrahim (2015) conducted a study on food prices and identified asymmetries in their behavior. He found a significant relationship between oil price increases and food prices in the long run, but no such relationship between oil price decreases and food prices. Moreover, he discovered that only positive changes in prices had a significant impact on food price inflation in Malaysia.

Several studies, including those by Hamilton (2012), Eltony and Al-Awadi (2001), Mork (1989), Mork et al. (1994), and Aleksandrova (2016), have confirmed a negative correlation between oil prices and gross domestic product (GDP). Umar et al. (2021) argue that the relationship between food and oil prices is influenced by current events and the structure of the economy, emphasizing the importance of considering these factors when developing policies for food security and price stability.

Multiple studies, such as those by Alghalith (2010), Nazlioglu et al. (2013), Gilbert and Morgan (2010), Minot (2014), and Abdlaziz et al. (2016), have concluded that unstable food prices disproportionately affect the poor, as they spend a larger share of their meager wages on food. Bathla et al. (2017) suggest that as food costs rise, wage rates will also increase, impacting public and private investment. This, in turn, may result in a decline in capital investment.

Other studies, including those by Baffes (2010), Harri and Hudson (2009), Alom et al. (2013), Du et al. (2011), and Chang and Su (2010) have examined the volatility of individual food commodity prices. However, their findings vary across different commodities, and the transmission mechanisms between oil and food prices have shown variation over time.

The recent global hike in agricultural commodity prices has adversely affected Nigeria's growth, as well as the growth of other countries heavily reliant on agricultural trading for foreign exchange earnings and local consumption. These nations' growth and development frameworks heavily rely on the stability and amount of their foreign exchange earnings (Harri et al., 2011). While short-term increases in global commodity prices may initially benefit foreign exchange earnings, continued price increases can lead to market-induced speculation and long-term issues (Tadesse et al., 2016).

Changes in food prices have socio-economic effects, including hunger, malnutrition, and macroeconomic instability. Governments often intervene to mitigate the effects of rising prices, but if improper countermeasures are implemented, both domestic and international efforts to reduce food price rises can distort food markets and lead to resource misallocation (Braun and Tadesse, 2012).

The current study aims to fill a research gap by investigating the relationship between oil prices and food prices in Nigeria, specifically during the COVID-19 pandemic. It also aims to examine the impact of transmission mechanisms such as exchange rates, monetary policy rates, and narrow money on food prices. Previous studies have not explored these aspects, nor have they considered the impact of the COVID-19 period and COVID-19 cases on food price inflation.

3. Methodology and empirical data

Most studies in similar fields in the past examine the relationship between oil and food prices using time series data techniques which include co-integration, Error correction technique, Granger causality tests, etc. The technique helps in evaluating short and long-run interactions. In most previous studies they only presume a symmetric relationship between food prices and oil prices. Hence, they are not enough to capture potential asymmetries in the food price dynamics that may arise from variables such as public policy, market interaction and others.

The NARDL approach proposed by Shin et al. (2014) is a modeling technique that allows for both long-run and short-run asymmetries in a variable of interest, making it an improvement over the standard ARDL model developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The NARDL approach is a nonlinear functional form that is used to model the relationship between variables. The NARDL approach extends the ARDL framework to capture potential nonlinear relationships between the variables. It allows for investigating asymmetric and threshold effects in the long-run and short-run dynamics. The NARDL model incorporates lagged values of the variables and includes additional terms to account for nonlinear effects. For instance, a NARDL(1,1) model with asymmetry and threshold effects can be represented as:

$$Y_t = \alpha + \beta Y_{(t-1)} + \gamma X_{(t-1)} + \delta_1 Y_{(t-1)} + \delta_2 X_{(t-2)} + \theta D_t + \varphi(Y_{(t-1)} - \theta X_{(t-1)}) + \varepsilon_t$$

Here, D_t represents a dummy variable capturing asymmetry, and θ denotes the threshold parameter. The NARDL model can be estimated using similar techniques as the ARDL model, such as OLS or MLE. The estimation results allow for investigating the existence and significance of nonlinear effects, including threshold effects and asymmetry. Appropriate statistical tests, such as the Wald test or likelihood ratio test, can be employed to assess the significance of the nonlinear terms. In this particular study, the NARDL approach is used to examine the impact of oil prices, exchange rate, monetary policy rate, narrow money, COVID-19 cases, and the COVID-19 period on the food price index in Nigeria. Thus, the Non-linear functional form was specified as:

$$F_P = f(O_P+, O_P-, E_r+, E_r-, M_2+, M_2-, C_{nc}, C_p,) \quad (1)$$

Where:

F_P is Food price inflation, O_p is the crude oil price, C_{nc} stands for COVID-19 new cases, C_p is COVID-19 period, E_r is the exchange rate of Naira to US Dollar and M_2 is Broad money.

Note that: the non-linear functional form of the COVID-19 case and COVID-19 period is not taken because it is assumed to be linear in nature.
In this regard, the model becomes

$$F_P = f\left(O_P+, O_P-, E_r+, E_r-, M_2+, M_2-, C_{nc}, C_p, \mu_t\right) \quad (2)$$

Where μ_t represents the stochastic error term at present time. The econometric model becomes:

$$Fp = \alpha + \beta_0 Op^+ + \beta_1 Op^- + \beta_2 Er^+ + \beta_3 Er^- + \beta_4 M_2^+ + \beta_5 M_2^- + \beta_6 C_{nc} + \beta_7 C_P + \mu_t \quad (3)$$

Hence, equation 3 was employed in the analysis.

3.1. Data Issues and measurement of variables

In analyzing the impact of oil price on food prices before and during the pandemic, macroeconomics variables were sourced from the World Development Indicators (WDI), data on coronavirus cases was gotten from Worldometer and data on crude oil from statista. To really examine this impact, monthly data from January 2018 to December 2021 of the following variables were used:
Food price (F_p): this is measured using monthly average prices of selected food gotten from the National Bureau of Statistics.
Oil price (O_p): crude oil average production price per barrel measured in US $ and sourced from the Central Bank of Nigeria online database.
Exchange rate (E_r): The official exchange rate of United States dollars to the Nigerian naira was employed to cater to the exchange rate, and it was sourced from the Central Bank of Nigeria online database.
Total number of COVID-19 new cases (C_c): This was gotten from the National Centre for Disease Control (NCDC).
A dummy variable (C_p) was used to represent the period of COVID-19: The value of 1 was assigned to the pandemic period while the value of 0 was assigned to the period without the pandemic. This dummy variable was included in the analysis to capture the impact of the pandemic on the variables of interest.

3.2. Estimation procedure

A trend analysis of the data is shown, and then the descriptive and correlation statistics. A pre-estimation technique using unit-roots of Augmented Dicky Fuller and Phillip Peron will be employed to ascertain if the NARDL estimation techniques is appropriate. Model selection criteria using the akaike information criteria top 20 of the model was employed to ascertain the best ARDL coefficient model followed by the bound test to ascertain if the model is co-integrated and has a long-run relationship, The NARDL analysis will also be fully employed due to the asymmetrical nature of the data. Finally, a post-estimation test will be carried out.

3.3. Trend of oil prices and food prices during COVID-19 in Nigeria

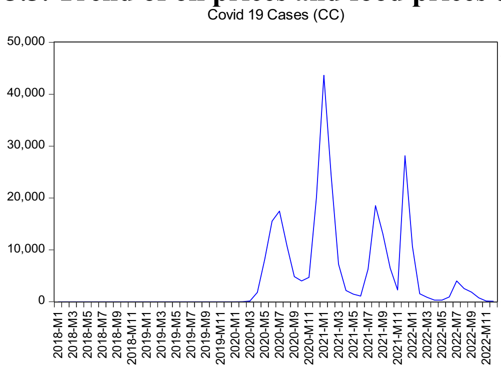


Figure 1A. Trend in COVID-19 cases

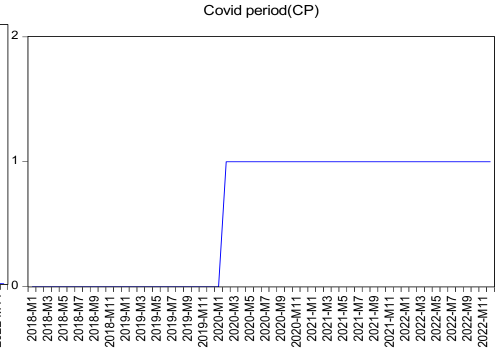


Figure 1B. Trends in COVID-19 period

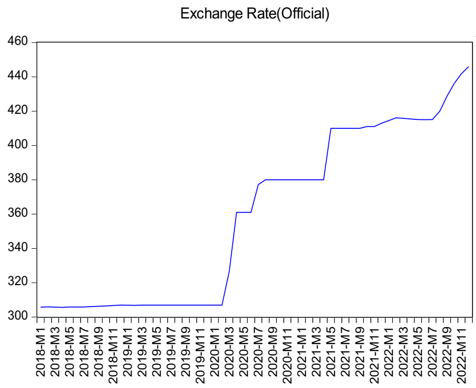


Figure 1C. Trends in Exchange Rate

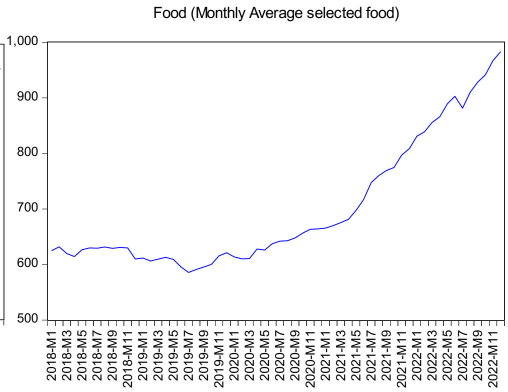


Figure 1D. Trends in Food Price

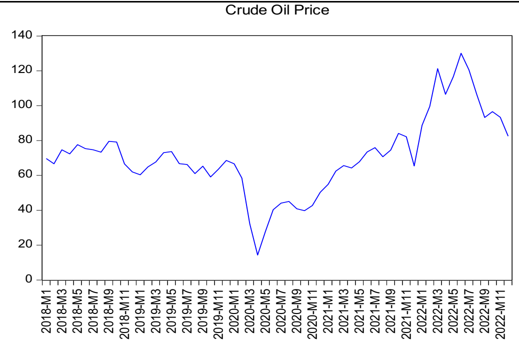


Figure 1E. Trends in Crude oil price
Source (figure 1A-E): Authors computation, 2023.

Trend Analysis

Figures 1A-E above display the trends of oil prices, food price inflation, and other variables in Nigeria before and during the COVID-19 pandemic. Here is a description of each figure. Figure 1A represents the trend of COVID-19 cases. The Y-axis shows the number of cases, while the X-axis shows the month and year. The graph indicates that the first case was reported in February 2020, and the highest number of cases occurred in January 2021. Figure 1B shows the graph of the COVID-19 period. The Y-axis represents the number of periods, and the X-axis displays the month and year. From the graph, it is evident that no COVID-19 cases were reported until February 2021 and continue to the present. Figure 1C presents the graph of the official exchange rate. The Y-axis represents the rate, while the X-axis shows the month and year. The graph demonstrates an increasing trend from 2001 to 2021. Figure 1D displays the graph of average monthly food price inflation. The Y-axis represents prices, and the X-axis shows the month and year. The graph indicates that food price inflation is not stable but exhibits an upward trend. Figure 1E represents the trend of crude oil. The Y-axis shows the international crude oil price, while the X-axis displays the month and year. The graph does not exhibit a specific pattern of trend but shows a zigzag pattern.

4. Empirical results

4.1. Preliminary analyses

4.1.1. Descriptive statistics: The table one below presents the results of the descriptive statistics of the variables used in this research.

Table 1. Descriptive statistics of the variables

	F_p	O_p	C_p	C_c	E_r
Mean	699.3773	71.02800	0.583333	4439.700	359.0264
Median	639.6178	68.19500	1.000000	306.5000	369.0950
Maximum	983.1491	130.1000	1.000000	43635.00	445.9705
Minimum	585.7063	14.28000	0.000000	0.000000	305.6100
Std. Dev.	114.5853	22.50544	0.497167	8348.548	50.32242
Skewness	1.094556	0.333639	-0.338062	2.641467	0.119577
Kurtosis	2.795061	3.663613	1.114286	10.63806	1.356003
Jarque-Bera	12.08554	2.214104	10.03265	215.6234	6.899806
Probability	0.002375	0.330532	0.006629	0.000000	0.031749
Sum	41962.64	4261.680	35.00000	266382.0	21541.58
Sum Sq. Dev.	774657.4	29883.20	14.58333	4.11E+09	149408.4
Observations	60	60	60	60	60

Source: Authors computation 2023

Table 1 above provides descriptive statistics for a dataset with 60 observations. It includes the mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera test results, and other statistical measures for various variables. According to Table 1, the COVID-19 cases (CC) have the highest mean, followed by the COVID-19 period (C_p), food price (F_p), exchange rate (E_r), and oil price (Op) in descending order. Standard deviation measures the volatility of a dataset. Large values indicate a higher level of volatility, whereas small values suggest less volatility. In this dataset, the COVID-19 period (C_p) and Oil price (O_p) exhibit low standard deviation values due to their small datasets. Skewness measures the asymmetry of the data distribution. Except for the Covid-19 period (C_p), all variables have positively skewed distributions. Kurtosis reveals the shape of the data distribution. Values less than 3 indicate a platykurtic distribution, which means the distribution is flatter compared to the normal distribution. On the other hand, values greater than 3 indicate a leptokurtic distribution, signifying a peaked distribution. In Table 1, C_p, E_r, and FP have kurtosis values less than 3, while C_c and O_p have values greater than 3, indicating their distributions are skewed. The Jarque-Bera test indicates the normality of the data distribution, and the associated probability determines whether the null hypothesis is accepted or not.

4.2. Correlation

Table 2 below presents the results of the associations among the variables.

Table 2. Correlation Matrix

	C_c	C_p	E_r	F_p	O_p
C_c	1.000000				
C_p	0.453240	1.000000			
E_r	0.337164	0.889268	1.000000		
F_p	0.054987	0.627578	0.866347	1.000000	
O_p	-0.247892	0.071090	0.387745	0.705121	1.000000

Source: Authors computation 2023

Table 2 above shows the correlation matrix of the relationship between the variables. Food price (F_p) shows a weak positive relationship with C_c, but a strong positive relationship with other variables.

4.1.3. Multicollinearity test

Table 3 below presents the results of the multicollinearity test using the variance inflation factor (VIF).

Table 3. Variance Inflation Factor

	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
C_c	3.77E-07	1.814972	1.409581
C_p	630.3235	20.05940	8.358082
Er	0.071856	515.0644	9.761639
O_p	0.081673	24.69807	2.219175
C	4895.822	267.0934	NA

Source: Authors computation 2023

Table 3 shows the variance inflation factor for the variables under study. The VIF is used to test for the presence or absence of multicollinearity. From the above, using the centered VIF, it is clear that there is an absence of multicollinearity because the corresponding centered VIF figures are less than 10. According to the rule of thumb, if the corresponding figures are greater than 10, it shows that there is the presence of multicollinearity and vice versa.

4.1.4. Stationarity test

Tables 4A & B below present the results of the stationarity tests of the variables used in this research.

Table 4A. Test for stationarity (ADF)

Variables	At level		At first difference		Remark
	T.Statistics	Probability	T. Statistics	Probability	
C_c	-4.202680	0.0015***			1(0)
C_p	-1.169891	0.6818	-7.615773	0.0000***	1(1)
Er	0.428348	0.9826	-5.995185	0.0000***	1(1)
F_p	4.382846	1.0000	-5.325094	0.0000***	1(1)
O_p	-1.516761	0.5183	-6.337723	0.0000***	1(1)

** denotes significance at 5% level, *** denotes significance at 1% level
Source: Authors computation 2023

Table 4B. Test for stationarity (PP)

Variables	At level		At first difference		Remark
	Statistics	Probability	Statistics	Probability	
C_c	-3.519307	0.0108***			1(0)
C_p	-1.169891	0.6818	-7.615774	0.0000***	1(1)
E_r	0.282126	0.9754	-6.014395	0.0000***	1(1)
F_p	4.272199	1.0000	-5.520502	0.0000***	1(1)
O_p	-1.608763	0.4718	-6.207007	0.0000***	1(1)

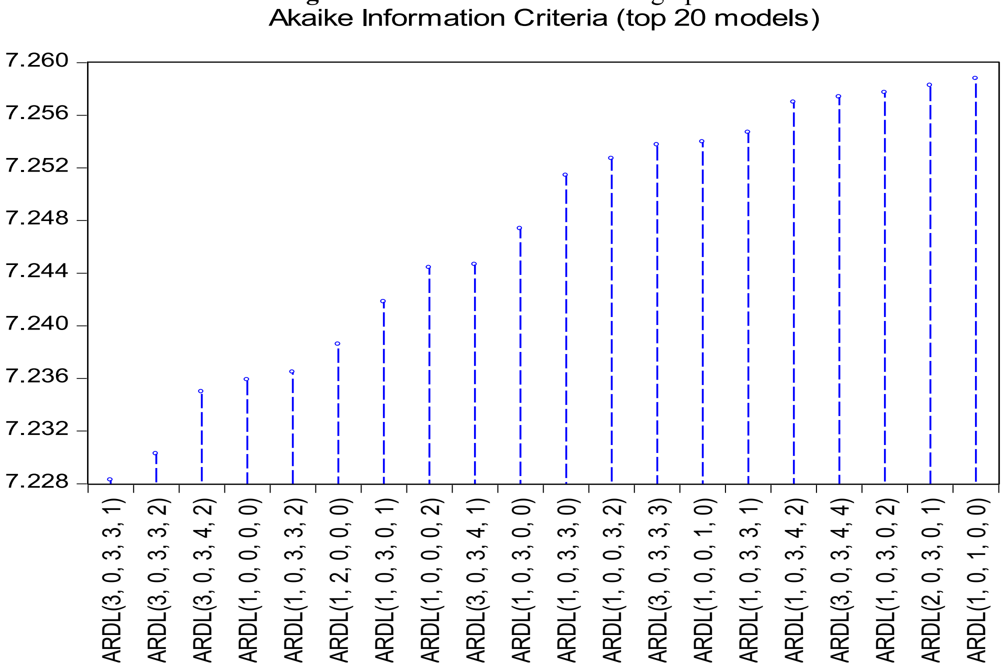
** denotes significance at 5% level, *** denotes significance at 1% level
Source: Authors computation 2023

The Augmented Dickey-Fuller (ADF) and Phillip Peron (PP) are the two unit root tests used. Augmented Dickey-Fuller (ADF) and Phillip Peron (PP) show the same pattern of stationarity, they both show that all variables are stationary at 1st difference except C_c. which is stationary at level (Figure 4A & B). The mixture of I(0) and I(1) of our variables necessitate the use of ARDL methods in this study.

4.1.5. Model selection

Figure 6 below presents the graph of the model selection, using Akaike information criteria.

Figure 2. Model selection criteria graph



Source: Authors computation 2023

The top 20 akaike information criteria of the model are used to display the results of the model selection criteria in the graph above. The best model, ARDL (3, 0, 3, 3, 1), is evident from Figure 2 and was selected because it has the lowest AIC.

4.2. Results and findings

4.2.1. ARDL results

Table 5. Results of ARDL (3, 0, 3, 3, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
F_p(-1)	0.772905	0.134182	5.760143	0.0000
F_p(-2)	-0.116807	0.175755	-0.664603	0.5099
F_p(-3)	0.256484	0.134754	1.903343	0.0639
C_c	-6.33E-05	0.000178	-0.355103	0.7243
C_p	-0.162585	8.350568	-0.019470	0.9846
C_p(-1)	-3.873819	12.47251	-0.310589	0.7576
C_p(-2)	-2.663977	13.24541	-0.201125	0.8416
C_p(-3)	-34.71333	13.52925	-2.565799	0.0140

E_r	0.545137	0.256456	2.125652	0.0395
E_r(-1)	0.015479	0.310284	0.049887	0.9604
E_r(-2)	0.582486	0.272320	2.138975	0.0383
E_r(-3)	-0.423944	0.186732	-2.270334	0.0284
O_p	0.319636	0.153275	2.085375	0.0432
O_p(-1)	-0.287226	0.165162	-1.739059	0.0894
C	-169.4345	37.98416	-4.460663	0.0001
R-squared	0.996495			
Adjusted R-squared	0.995326			
F-statistic	852.8162			
Prob(F-statistic)	0.000000			
Durbin-Watson stat	2.012513			

Source: Authors computation 2023

Table 5 above shows the result of the ARDL coefficient. Food price response instantly to changes in O_p (0.319636), this is in line with the apriori expectation and it is significant at the 5% level because its probability is 0.0432. This means that a 1% increase in oil price will instantly lead to a 32% increase in the prices of food. The negative coefficient of O_p (-1) (-0.287226) on food price in the 1st lag will not be reckoned with because it's not in line with the theory. The coefficient of C_c (-6.33E-05) shows a negative and insignificant impact on food prices while COVID -19 period (C_p) also shows a negative and insignificant impact on food prices in the present period, Lag 1 and Lag 2 but has a negative and significant impact on food price in the lag 3 period. The coefficient of E_r(0.545137) shows that the exchange rate has a positive and significant impact on food price in the present and 2nd lag period. This is in line with the apriori expectation.

On the same table food price F_P shows a positive impact on itself in the first lag. The impact is observed to be significant at a 1% level in the first period but insignificant in the second and third period. The R^2 demonstrates that the model accounts for nearly 99% of the variation in F_p. This demonstrates that the model is the only model that can account for F_p. Around 99% of the differences are shown by the R^2 adjusted, which is quite close to the R^2. This demonstrates that there is no duplication. The goodness of fit is significant at the 1% level of significance, according to the F-statistics (852.8162) and Prob (F-statistic) (0.000000). The Durbin-Watson statistic (2.012513), which indicates the goodness of fit, is about 2.

4.2.2. Cointegration test for ARDL

Bound test was used to examine the presence of long-run relationships among the variables in the model. The result is presented in Table 6.

Table 6. Bound Test

Test Statistic	Value	K
F-statistic	7.125921	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Source: Authors computation 2023

The calculated bound test, represented by the F-statistic Value of 7.125921 in the table is higher than the 1% critical bound value (3.74 – 5.06). This suggests convergence, demonstrating long-term cointegration among the variables in the coming years.

4.2.3. Long-run results for ARDL

The results of long-run relationships among the variables are presented in Table 7.

Table 7. ARDL long-run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C_c	-0.000724	0.002084	-0.347395	0.7300
C_p	-473.742310	210.711245	-2.248301	0.0299
E_r	8.226641	3.008932	2.734074	0.0091
O_p	0.370750	1.330568	0.278640	0.7819
C	-1938.205903	860.306422	-2.252925	0.0295

Source: Authors computation 2023

Table 7 above showcases the long-run relationship among the variables. Oil price (O_p) (0.370750) and (E_r)(8.226641) have a positive long-run impact on Food price but while the Exchange rate impact is significant, the impact of oil price is not significant. This is because their respective probabilities are 0.0091 and 0.7819 respectively while COVID-19 cases C_c(-0.000724) andCOVID-19 period C_p (-473.742310) shows a negative impact on food price and while COVID-19 cases are insignificantly negative COVID-19 period is significantly negative on Food price because their probability is 0.7300 and 0.0299 respectively.

4.2.4. Short-run results for ARDL

The results of short-run relationships among the variables are presented in Table 8.

Table 8. Short-run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
$D(F_p(-1))$	-0.139677	0.130208	-1.072717	0.2895
$D(F_p(-2))$	-0.256484	0.134754	-1.903343	0.0639
$D(C_c)$	-0.000063	0.000178	-0.355103	0.7243
$D(C_P)$	-0.162585	8.350568	-0.019470	0.9846
$D(C_p(-1))$	2.663977	13.245409	0.201125	0.8416
$D(C_p(-2))$	34.713335	13.529247	2.565799	0.0140
$D(E_r)$	0.545137	0.256456	2.125652	0.0395
$D(E_r(-1))$	-0.582486	0.272320	-2.138975	0.0383
$D(E_r(-2))$	0.423944	0.186732	2.270334	0.0284
$D(O_p)$	0.319636	0.153275	2.085375	0.0432
$ECM(-1)$	-0.087418	0.042158	-2.073601	0.0443
Cointeq = FP - (-0.0007*CC -473.7423*CP + 8.2266*ER + 0.3707*OP -1938.2059)				

Source: Authors computation 2022

The ARDL co-integration equation, the short-run impact, and the ECM are displayed in Table 8 above. The short-term effect is identical to that described by the ARDL coefficient in Table 5. The ECM's coefficient (-0.087418) exhibits a negative sign and it is significant. It indicates that there is convergence and the speed of adjustment is about 9%. The implication is that it takes about 12 months for this model to return to equilibrium.

4.2.5. Diagnostic Tests for ARDL

The results of various diagnostic tests to show how good the ARDL model is and its suitability for prediction are as follows.

Table 9. Breusch-Pagan-Godfrey tests

Tests	Statistics	Probability values
Breusch-Godfrey Serial Correlation LM Test:	0.505988	0.6067
Heteroskedasticity Test: Breusch-Pagan-Godfrey	1.109246	0.3782

Source: Authors computation 2023

Table 9 above displays the results of the Breusch-Godfrey LM test and the Breusch-Pagan-Godfrey heteroskedasticity residual diagnostic test for serial correlation. Their individual probability results are all more than 5%, therefore we accept the null hypothesis that serial correlation, heteroskedasticity, and specification error are all absent.

4.3. Nonlinear ARDL

Most studies did not distinguish between positive and negative changes in oil prices, hence the application of the symmetric technique of ARDL. However, the theory tells us that the model will be asymmetric where the response of the dependent variable to positive changes in the independent variable is different from negative changes. This can lead to discrepancies in the results. Hence the need to employ the NARDL model in other to compare its results with the ARDL results and explain the positive and negative changes.

4.3.1. NARDL results

The results of NARDL analysis are presented in Table 10.

Table 10. Results of the NARDL Model (1, 0, 3, 0, 0, 1, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
$Fp(-1)$	0.883106	0.055021	16.05031	0.0000
Cc	-0.000111	0.000176	-0.630500	0.5316
Cp	-2.026355	9.070862	-0.223392	0.8242
$Cp(-1)$	-9.984940	12.56183	-0.794863	0.4309
$Cp(-2)$	-7.578298	13.58933	-0.557665	0.5798
$Cp(-3)$	-18.27936	9.875134	-1.851049	0.0707
Er_POS	0.710214	0.207766	3.418342	0.0013
Er_NEG	-8.161116	9.514492	-0.857756	0.3956
Op_POS	0.491959	0.239708	2.052328	0.0460
$Op\_POS(-1)$	-0.536003	0.274541	-1.952363	0.0571
Op_NEG	0.015222	0.128391	0.118559	0.9062
C	67.61779	31.90382	2.119426	0.0396
R-squared	0.995943			
Adjusted R-squared	0.994951			
F-statistic	1004.302			
Prob(F-statistic)	0.000000			
Durbin-Watson stat	2.209476			

Source: Authors computation 2023

Table 10 presents the results of the nonlinear model of oil and food price. Food price ($Fp(-1)$) (0.883106) has a positive impact on itself and the impact, as shown in the table, is significant because the p-value is 0.0000. COVID-19 cases (Cc) (-0.000111) have a negative and insignificant impact on food prices because their p-value is 0.5316. COVID-19 period (Cp) lag 1, 2, 3 and the present period have a negative and insignificant impact on food price. This is because its coefficient, -2.026355, -9.984940, -7.578298 and -18.27936 respectively are not significant at the 5% level.

Table 10 also shows that a dollar rise in the oil price (O_p)(0.491959) will result in a 49% rise in food price instantly and the relationship is significant because its p-value is 0.0460 while for every $1 fall in the oil price($Op_NEG$) (0.015222) will result to 1.5% insignificant fall in food price because its p-value is 0.9062. This is in line with the apriori expectation because the food price is not expected to react instantly to a reduction in oil price. Similarly, a rise in exchange rate (Er_POS)(0.710214) will result in an approximately 71% significant increase in food price because its p-value is 0.0013 while a fall in exchange rate (Er_NEG)(-8.161116) will result in an insignificant decrease in food price because its p-value is 0.3956.

The R^2 demonstrates that the model accounts for nearly 99% of the variation in Fp. This demonstrates that the model account for high variation in food price, Fp. Around 99% of the differences are shown by the R^2 adjusted, which is quite close to the R^2. This demonstrates that there is no duplication. The goodness of fit is significant at the 1% level of significance, according to the F-statistics (1004.302) and Prob (F-statistic) (0.000000). The Durbin-Watson statistic, or 2.209476, indicates the goodness of fit.

4.3.2. Co-integration test for NARDL

Bound test was used to examine the presence of long-run relationships among the variables in the model. The result is as presented in Table 11.

Table 11. Result of NARDL Bound Test

Test Statistic	Value	K
F-statistic	4.683772	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Authors computation 2023

The NARDL bound test above shows the f-statistic value of 4.683772 which is above the 1% bound level of 3.15– 4.43. This is an indication that oil price can influence food price in the long run and the null hypothesis is rejected.

4.3.3. Long-run results for NARDL

The results of long-run relationships among the variables are presented in Table 12.

Table 12. NARDL long-run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Cc	-0.000948	0.001636	-0.579423	0.5652
Cp	-323.960222	127.677103	-2.537340	0.0147
Er_POS	6.075716	2.340638	2.595752	0.0127
Er_NEG	-69.816486	78.732404	-0.886757	0.3799
Op_POS	-0.376789	1.309800	-0.287669	0.7749
Op_NEG	0.130220	1.081447	0.120412	0.9047
C	578.454711	23.784762	24.320390	0.0000

Source: Authors computation 2023

Table 12 above showcases the NARDL long-run impact of oil on food prices. An increase or a decrease in Oil price (DO_p) will lead to an insignificant decrease in food price in the long run. In the same table, the coefficients of increase in Exchange rate (E_r) (6.075716) and decrease (-69.816486) show a positive and negative long-run relationship with food price respectively and the impact of the rise in the exchange rate is significant. Finally, the COVID-19 period and COVID-19 cases both have a negative impact on the food price. However, it is only the impact of the COVID-19 period on food price that is significant.

4.3.4. Short-run results for NARDL

The NARDL results of short-run relationships among the variables are presented in Table 13.

Table 13. NARDL Short-run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
$D(Cp)$	-0.000111	0.000176	-0.630500	0.5316
$D(Cp)$	-2.026355	9.070862	-0.223392	0.8242
$D(Cp(-1))$	7.578298	13.589334	0.557665	0.5798
$D(Cp(-2))$	18.279357	9.875134	1.851049	0.0707
$D(Er\_POS)$	0.710214	0.207766	3.418342	0.0013
$D(Er\_NEG)$	-8.161116	9.514492	-0.857756	0.3956
$D(Op\_POS)$	0.491959	0.239708	2.052328	0.0460
$D(Op\_NEG)$	0.015222	0.128391	0.118559	0.9062
$ECM\ (-1)$	-0.116894	0.055021	-2.124526	0.0392
Cointeq = FP - (-0.0009*CC -323.9602*CP + 6.0757*ER_POS -69.8165 *ER_NEG - 0.3768*OP_POS + 0.1302*OP_NEG + 578.4547)				

Source: Authors computation 2022

Table 13 above showcases the NARDL co-integration equation which is not different from the coefficient of NARDL on table 10 above, the short-run impact and the ECM. The coefficient of the ECM (-0.116894) shows a negative sign and a high speed of adjustment. This means that about 12% of the disequilibrium is corrected in a month and significant at a 1% level of significance because its probability is 0.0000. This means that the disequilibrium will be corrected in about 9 months.

4.3.5. Diagnostic Tests for NARDL

The results of various diagnostic tests to show how good the NARDL model is and its suitability for prediction are as follows:

Table 14. Breusch-Pagan-Godfrey tests for NARDL model

Tests	Statistics	Probability values
Breusch-Godfrey Serial Correlation LM Test:	3.219202	0.0732
Heteroskedasticity Test: Breusch-Pagan-Godfrey	1.875021	0.0947

Source: Authors computation 2022

The diagnostic test in Table 14 displays the results of the Breusch-Godfrey LM test and the Breusch-Pagan-Godfrey heteroskedasticity residual diagnostic test for serial correlation. Their individual probability results are all more than 5%, therefore we accept the null hypothesis that serial correlation, heteroskedasticity, and specification error are all absent.

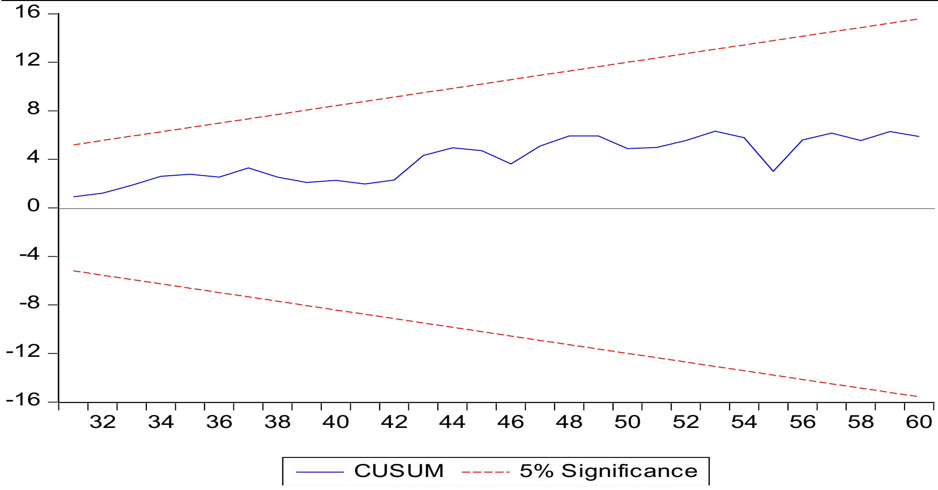


Figure 3. Result of the Stability Test
Source: Authors computation 2022

The stability test outcome utilizing the Cumulative Sum test is shown in Figure 3. The blue line falls within the red lines in the result, therefore we reject the null hypothesis—which is referable—that the regression coefficients are constant and changing systematically.

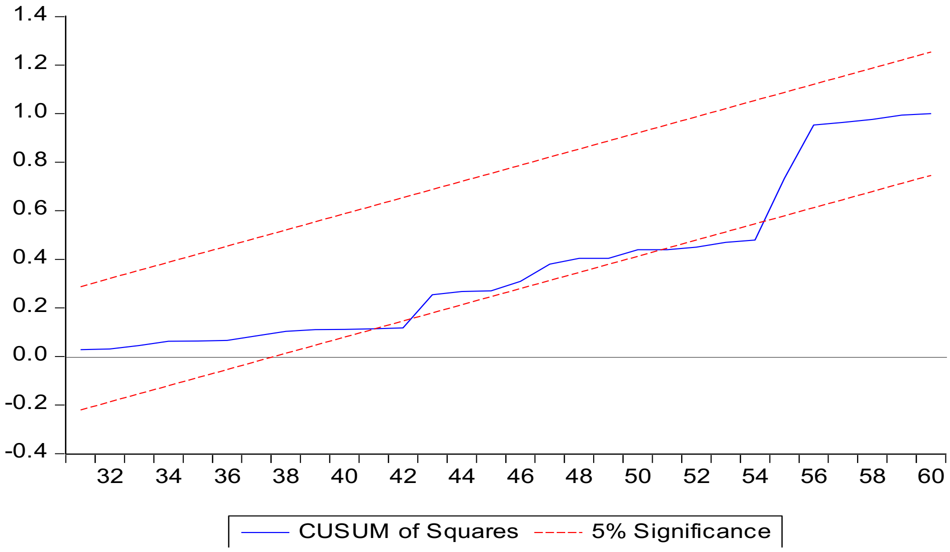


Figure 4. Result of the Stability Test
Source: Authors computation 2022

The stability test outcome utilizing the Cumulative Sum of the Square test is shown in Figure 9 above. The blue line, which is outside the red lines as a result, leads us to reject the null hypothesis, which is that the regression coefficients are stable and evolving systematically.

4.4. Discussion of the findings

This study has been able to provide evidence for long-run and short-run asymmetry in oil and food prices in Nigeria. This is in line with previous studies, Abdulaziz et al. (2016), Ibrahim (2015) and Cunado and de Gracia (2005). Both linear and nonlinear ARDL established the presence of both long-run and short-run relationships between oil price and food price. However, the nonlinear ARDL was able to disaggregate these effects into when the oil price increase or decrease to see their effects on food prices. The results show that while there is a significant relationship in the long run and short run between an increase in oil price and food price inflation, the relationship between a decrease in the oil price to food price for the short-run and long-run was not significant. The implication is that while there is some evidence of price pass-through for an increase in the price of oil, the effect was not felt for a corresponding decrease in food price when the price of oil falls. This is an indication of market power which may be due to some market forces that are preventing the price of food to fall when the oil price drops (Ibrahim, 2015).

5. Conclusions and recommendations

This study examined the impacts oil price has on food price in an oil-exporting and refined oil-importing country before and during COVID-19 in Nigeria. Considering the roles of exchange rate and the effect of the COVID-19 pandemic period and COVID-19 cases on shaping food price; these variables were included in our study in order to identify symmetric and asymmetric relationships between the prices of food and oil over the long and short terms, the researcher uses the ARDL and NARDL models for the investigation. Both long-term and short-term asymmetries were shown to exist, according to the investigation. The correlation matrix in the study shows that food price has a strong positive relationship with Oil price and other variables except for COVID-19 cases which have a weak positive relationship with Food price in Nigeria. When analyzing over time, rising oil prices cause food prices to rise, whereas falling oil prices have no effect on food prices. So, the issue with food price volatility is still a short- and long-term supply phenomenon. Although while the demand side of the food industry is crucial, the supply side is more likely to experience shocks due to changes in the market for oil prices.

Considering, the impact and policies that are associated with various monetary and exchange rates as it affects food price inflation before and during the COVID-19 pandemic, this paper suggests the following:

1. Continued support of local production of Food for our growing population at affordable price by banning all imported food items that can be produced locally. This will curb the menace of imported food and reduce over-reliance on foreign food.
2. Fixing all local refineries and granting license to more private refineries to reduce local pump price and eliminate fuel subsidy completely. Part of the funds used for subsidy of refined products should be invested into subsidizing local food crops farmers and other infrastructural and sectorial developments.
3. With the booming oil market, the stock of food needs to be increased to complement supply shortages during the pandemic.
4. Policy schemes such as price controls of essential food items should be put in place by the government and also laws debilitating against stockpiling should be promulgated and enforced for the sake of the lower half of the economy.
5. The activities of foreign exporters that visit farm gate for commodities should be quickly abolished in other to curb the rising prices of local commodities.
6. The Covid -19 period has come to stay and the Nigerian government has been able to manage its spread and people have been able to return to their various means of livelihood but it has left the already fragile economy that solely relies on imported food in shortage of food coupled with the rising inflation which is majorly imported.
7. The COVID-19 period is an eye opener to Nigeria and we recommend that Agricultural inputs should be provided that will make farmers grow food crops in a more mechanized approach in other to feed the nation and export its excesses.

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Author Contributions
Yusuf and Salau conceived the study and were responsible for the design and development of the data analysis and writing of the manuscript. Adeiza reviewed the manuscript and improve the quality to meet the journal's publication standard.

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