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Asymmetric effects of global oil price on food insecurity in Nigeria: A NARDL approach

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Abstract

This study investigates the short-run and long-run asymmetric effects of world oil price fluctuations on food insecurity in Nigeria, an oil-exporting country that paradoxically struggles with local oil refining and remains heavily reliant on fuel imports. The problem addressed is the disconnect between Nigeria's status as a crude oil exporter and its vulnerability to global oil price shocks, which exacerbate food insecurity through inflationary pressures, rising transportation costs, and exchange rate volatility. Using a Nonlinear Autoregressive Distributed Lag (NARDL) model, we analyze how positive and negative changes in oil prices affect food insecurity, while accounting for exchange rate movements and inflation from 1970-2020. The results reveal significant asymmetric effects, with negative oil price shocks having a more pronounced effect on food insecurity than positive shocks, both in the short and long run. Both positive and negative shocks consistently worsen food insecurity, suggesting that oil price volatility intensifies the fragility of Nigeria's food systems. The error correction mechanism indicates a fast speed of adjustment to long-run equilibrium. These findings highlight the need for policies to mitigate the adverse effects of global oil price volatility on food security in Nigeria, including stabilizing exchange rates, controlling inflation, and developing local oil refining capacity to reduce the economy's reliance on fuel imports. Strengthening food systems through diversification and sustainable agricultural practices is also critical.

1. Introduction

Over the years, global interest has been on oil price and food price. In recent years the sector suffered from serious persistence shocks in the energy market which consequently led to obstinate fluctuations in oil price. The shock outrageously increased oil price from USD 55 in 2005 to USD 147 in mid-2008. Oil prices traditionally have been more volatile than many other commodity or asset prices since World War II. Oil price volatility can come from international shocks caused by financial crises, strikes, wars and decreased oil production. An oil price shock is unexpected or unpredictable events that affect an economy either positively or negatively. The global food price shocks of 2007/2008, the 2010/2011 resurgence of food price spikes and rising food price in the recent times have drawn the attention of

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international organization, policy analysts and researchers on the issues related to price fluctuations as well as the driver and trigger of food price shocks.

Nigeria food insecurity is a condition of insufficient access to quality nutritious food; it is often rooted in shocks that interrupt the food production and distribution system in an area. Food security is influence by oil price fluctuation; food affordability and availability are reduced with the higher oil price, higher income increases food security. Food prices have been quite high across many countries in the last decade (Von Branu and Tadesse 2012; Minot, 2014; Shittu et al.,2017). The food price fluctuations of the past decade have also been linked to having substantial economic cost and exerted negative welfare impacts on many households especially the poor, small holder traders in Africa and other developing regions (FAO, 2011).

Food is in no doubt the most basic of all human survival need. Although so many efforts have been sunk in improving the quality as well as the production of world food supplies, food insecurity remains prevalent particularly in the global southern nations of Asia, and Africa. Malnutrition has resulted in deaths of many of its citizen. Failure to ensure food security has unavoidably resulted in many social problems including civil unrest and riot in many cities of the world (Behnassi et al., 2013). Many factors have attributed to fluctuation in food prices in recent years including policy shocks, monetary factors, extreme weather events, demand shocks and energy price (Tadessa et al., 2016). Pal and Mitra (2019) highlighted that price of energy is the primary driver of agricultural commodity price around the globe. Sharp changes in oil price affect different countries differently, depending on whether the country in question is an exporter of crude oil or an importer. For an importer or a consumer nation, rise in price of oil, an input of production, raises the cost of production, and hence can lead to (cost-push) inflation, lower economic growth, and even recession (Mordi and Adebiyi, 2010). This was the case in the US between 1948 and 1981 (Hamilton, 1983). On one hand, rise in oil price is beneficial to oil exporting countries as export receipt from a given quantity of oil increases (Blanchard, 2007). On the other hand, decline in oil price may hurt them in terms of decline in foreign revenue, economic recession, and sometimes political instability (Zhang et al., 2015).

It is clear that countries that may benefit from additional income from commodity price booms; yet, the benefit may be limited due to the Dutch disease syndrome plague (DDS). Besides, removal of subsidies on petroleum products by many governments in net oil-exporting countries in pursuit of market-based efficiency may increase domestic prices of petroleum products to international crude oil prices (Baig et al., 2007). This implies that oil price rise shocks filters into such economy via domestic fuel prices. Thus, the economies may also be affected by oil price increase in a fashion similar to that of net oil importers.

The relationship between oil price and food price is complex, higher oil price raise the cost of agricultural production in terms of direct fuel use on farm and transportation as well as other imports, high cost of food production raise food prices (Hang, 2015; Serra, 2013; Alom et al., 2011).Several studies (Nazlioglu and Soytas, 2011; Fowowe, 2016; Nwoko et al., 2016; Janda et.al 2018; Daniel et al., 2018; Zafeiriou et al. 2018; Abdulaziz, 2019;Anthony et al.2019; Ugwuh and Muhammad, 2019 etc) have been conducted on the relationship between oil price and food price changes as evidenced in the literature review section. However, there is dearth of study linking oil price to food insecurity. Further, these studies have mainly assumed symmetric effects of oil prices. Asymmetry may exist due to constraints placed on firms' adjustment to oil price shocks by resource reallocation effect. When oil price rises, sectors that use oil-intensive production processes decline. On the other hand, sectors that are less dependent on oil relatively expand. The engendered reallocation of resources, coupled with market imperfection constrains reverse adjustment when oil price falls. Factors of production do not readily move between sectors, despite falling oil price and declining costs of production; and consequent expansion in the energy-intensive sector. The sector could thus not fully expand in response to a unit fall in oil price as much as they shrank when oil price had risen by a unit. This shows that oil price changes (rise and fall in price) may lead to overall output loss (Jimenez-Rodriquez and Sanchez, 2003).

Ascertaining the magnitude and differential effects of a positive and negative change in oil price on food insecurity is the focus of the current study. Specifically, the objective of this study is to determine whether there is a long run relationship between global oil price and food insecurity in Nigeria and whether the long and short run effects of oil price on food insecurity in Nigeria asymmetric. This naturally lends itself to testing the following null hypothesis: First, there is no long run relationship between oil price and food insecurity. Second, the long run effects of oil price on food insecurity in Nigeria is symmetric and third, the short run effects of oil price on food insecurity in Nigeria is symmetric. The rest of the paper is structured as follows: Section 2 presents the literature review. The data and empirical model are presented in session 3. Results are discussed in section 4 while section 5 concludes.

2. Literature Review

The skyrocketing trend of oil price and food price in recent years has attracted the attention of researchers, policy makers and other stakeholders. It is believed that food prices are immensely influenced by oil prices because agriculture is traditionally energy intensive and thus oil price have direct linkage with agricultural commodity prices. When oil prices increase, agricultural input price also increase (Nazlioglu and Soytas, 2011).

This study was basedon Keynesian economics as the theory of overall spending in the economy sometimes to as aggregate demand, and its consequences on the economy as a whole, including both output and inflation, perhaps the most serious macroeconomic problem confronting the world economy today (Blinder 2008; Bawa et al., 2020).

A number of studies have focused on the causes of food price hike emphasizing the factors related to petroleum usage and price. For example, increased demand for bio-fuel as an alternative of conventional fossil fuel has been identified as one of the factors responsible for food price surge (Dioa et al., 2010; Janda et al., 2018). Arshad and Abdel (2009) investigated if there is a long-term relationship between petroleum and cereal price using monthly data over the period of January 1980 to March 2008. The bivariate co-integration approach using the Eagle-Granger two stage estimation procedures was applied and the result revealed unidirectional long-run causality from petroleum price to cereal price.

Gogoi (2014) investigated the long-run relationship between crude oil and world food commodity prices such as maize, rice, soybean and wheat between 1980-2011 using time series econometric technique. The co-integration test revealed that there is a long-run relationship between crude oil prices and agricultural produce. Nazlioglu and Soytas (2011) investigated oil price and food relationship using monthly data from 1980 to 2010 based on panel co-integration and causality test. The result showed that world oil price has significant impact on agricultural product price. Mc Phail et al. (2012) used SVAR model on monthly data from January 2000 to July 2011 and discovered oil price is a major variable that explained change in food price. Alghalith (2010) examined the correlation between food and oil price from Trinidad and Tobago from 1974 to 2007. The result shows a strong correlation between oil and food price.

Fowowe (2016) used structural breaks co-integration test and found no evidence of long run relationship between oil price and agricultural commodity price in South Africa implying that agricultural commodity price in South Africa is neutral to global oil price. According to Daniel et al. (2018), there is the presence of asymmetry in the long run oil price-food prices relationship while asymmetry was found to be absent in the short-run relationship. The result from their work concludes that oil price increase tends to increase food prices, while oil price reduction does not seem to be related to food price reductions in the long run. Neither the oil price increase nor decrease seems to be related to food prices in the short run. It is noteworthy that this study on asymmetric effect of oil price was on commodity prices and not on food security.

Taghizadeh-Hesary et al. (2018) analyzed the linkages between energy price and food prices using a panel-VAR model and data from 2000 to 2016 for eight Asian economies. Their results show that agricultural food prices respond positively to oil prices justifying a nexus between energy and food security via price volatility. However, this study did not explicitly analyses the energy food security nexus. Zafeiriou et al. (2018) analyzed the relationship between crude oil and agricultural (corn soybean) futures prices using ARDL model. Crude oil price was found to share a long run relationship with each of the agricultural commodity prices and the effect is significant both in the long run and short run. Anthony et al. (2019) carried out a study on crude oil price and agricultural produce namely maize and millet in Nigeria using quarterly data from 1981 to 2015. Adopting the exponential generalized autoregressive heteroskedasticity (EGARCH) Model, the result shows that crude oil have significant impact on agricultural growth.

Oseni (2018) considered the impact of oil price shock on agricultural commodity price in Nigeria. Using monthly data from 1997 to 2016, linear ARDL and Non –linear ARDL technique, they found out that oil price has positive impact on agricultural commodity prices. Baffes (2007), investigated the effect of crude oil price on the agricultural commodity from 1960 – 2005 and found that oil price has effect on agricultural commodity using time series analysis. Hao et al. (2013) observed a short and long-run cointegration between biodiesel and soybeans price, using weekly price series from January 2006 to December 2011. The result shows a positive effect of oil price on soybean price.

Alom et al. (2013) investigated the mean and volatility spillover effect of world oil price in selected Asia and pacific countries using autoregressive (VAR) and GARCH family model and daily observation from 2nd January 1995 to 30 April 2010. The result shows that world price have positive influence on food price. Nwoko et al. (2016) investigated the effect of oil price on volatility of food price in Nigeria from 2000-2013 using VECM and found that there is long-run relationship between oil price and food price volatility in Nigeria. Ano et al. (2014) assessed the impact of oil price on cocoa and sugar. The study used Bayesian multivariate model and monthly data from 2001 to 2003.The result shows there is a positive impact on agricultural products. Ugwuh and Muhammad (2019) analysed the effect of oil price shock on small scale agro allied enterprise in Benue State Nigeria from 1984 -2014using Vector Auto-Regression (VAR) model; the result shows that oil price has a negative effect on small scale agro allied enterprise. Eleni et al. (2018) examined the bivariate relationship between crude oil and agricultural commodity from 1988-2014 using ARDL co-integration approach, it was observed that crude oil price affects the price of agricultural products. Zhang and Qu (2015) investigated how price of agricultural commodities in China are affected by global shock of crude oil, they examined an extensive set of agricultural commodities and find out that the effect of oil shocks on majority of them are asymmetric.

Chen et al. (2010) examined the relationship between the oil price and global food prices from 3rd week of 2005 to 20th week of 2008.The study employed the ARDL method and the results revealed that the increment in the food price is significantly influenced by crude oil price. Esmaeili and Shokoohi (2011) examined the connection among price of food and macroeconomic variables using monthly data from 1961 to 2005 in US. They concluded that food production index has the highest impact on macroeconomic index, and there is no direct relationship between oil price and food price component. Avalos and Lombardi (2015) investigated the response of food price to oil price using VECM and monthly data from January 1986 to April 2012 for the US. The study found that corn price responds intensely to world demand shock than other commodities employed.

Olasunkanmi and Oladele (2018) examined the asymmetric impact of oil price shock on agricultural commodities in Nigeria from 1997 –2016, using a nonlinear autoregressive distribution lag (NARDL). The result shows that oil shock price have effect on food price. Abdulaziz (2019) examined the asymmetric effect of oil price on food price in Nigeria using quarterly data from 2010-2017 using a nonlinear autoregressive distribution lag, the result shows a positive effect of oil price shock on food price.

From the foregoing, the literature review shows that there are vast empirical studies on the effects of oil price on agriculture sector variables. However, these studies concentrated on the food or agricultural commodity prices. There is dearth of studies on oil price and food security. Moreover, majority of these studies assumed symmetric effects. The current study contributes to the literature by examining the asymmetric effects of global oil price on food insecurity using Nigerian data.

3. Data and Emprical Model

The Data for the study were obtained from secondary sources (see Table 1). The time series data used span from 1970 to 2020. Data on exchange rate, inflation rate, price of oil in the world market and food insecurity were obtained from FAO.

Table 1: Measurement and Sources of Data

Variable	Description &Unit of Measurement	Sources
Food insecurity	The number of people undernourished in Nigeria	FAO
Global or World oil price	West Texas Intermediate (WTI) crude oil price measured in US dollars	World Bank
Exchange rate	Official exchange rate, naira per US Dollar (period average) measured in %	World Bank
Inflation	The rate of change in consumer price index (%)	World Bank

Data were analysed using the nonlinear autoregressive distributed lag (NARDL) model. NARDL model developed by Shin *et al.* (2014), is a unified model capable of combining nonlinearity in the long relationship and error correction mechanism coherently. The NARDL model is an extension of ARDL model. The common assumption that the underlining co-integrating relationship may be presented as a linear combination of the underlining non-stationary may be excessively restrictive. In general, the long run cointegrating relationship may also be subject to asymmetry or non-linearity. The starting point of the model may be given as:

$$\boldsymbol{y} = \boldsymbol{f}(\boldsymbol{x}_t^+, \boldsymbol{x}_t^-) \quad (1)$$

Where y is a function of the positive and negative values of the independent variables indicated by $x_t^+ and\ x_t^-$ respectively.

NARDL is an asymmetric extension to the well-known ARDL model of Pesaran and Shin (1999) and captures both long-run and short-long asymmetries in the variable of interest. The NARDL can be used to show the asymmetric long run equation:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \quad (2)$$

Where β^+ and β^- are the associated long run parameters to be estimated.

The x_t and k ×1 vector of regressors decomposition as defined:

$$y_t = x_0 + x_t^+ + x_t^- \quad (3)$$

where x^+ and x^- are partial sum processes of positive and negative changes in x^t.

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \ldots \quad (4)$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \ldots \quad (5)$$

The empirical NARDL equation for the asymmetric effects of oil price on food security is given as:

$$\Delta FS_t = \varphi_0 + \sum_{i=1}^{p} \varphi_{1i} \Delta FS_{t-i} + \sum_{i=0}^{q} (\varphi_{2i}^+ \Delta WOP_{t-i}^+) + \sum_{i=0}^{q} (\varphi_{3i}^- \Delta WOP_{t-i}^-) + \sum_{i=0}^{h} \varphi_{4i} \Delta Exch_{t-i} + \sum_{i=0}^{n} \varphi_{5i} \Delta Inf_{t-i} + \beta_1 FS_{t-1} + \beta_2 WOP_{t-1}^+ + \beta_3 WOP_{t-1}^- + \beta_4 Exch_{t-1} + \beta_5 Inf_{t-1} + \varepsilon_t \quad (6)$$

Where:

FS = Food insecurity
Exch = Exchange rate
Inf = Inflation rate
WOP =Global oil price
p, q, h and n = lag values
Δ = difference operator.
t = time trend
$\varphi_1 - \varphi_5$ are the short run coefficients, while $\beta_1 - \beta_5$ are the long run coefficients.

Based on Equation (6), the error correction model (ECM) cab be specified as follows:

$$\Delta FS_t = \varphi_0 + \sum_{i=1}^{p} \varphi_{1i} \Delta FS_{t-i} + \sum_{i=0}^{q} (\varphi_{2i}^+ \Delta WOP_{t-i}^+) + \sum_{i=0}^{q} (\varphi_{3i}^- \Delta WOP_{t-i}^-) + \sum_{i=0}^{h} \varphi_{4i} \Delta Exch_{t-i} + \sum_{i=0}^{n} \varphi_{5i} \Delta Inf_{t-i} + \lambda ECM_{t-1} + \varepsilon_{2t} \quad (7)$$

Where λ is the coefficient of the error term and ECM is error correction term.

4. Results

Summary statistics of the variables used in analysis

The summary statistics of the variables used in the analysis is presented in Table 2. The results are presented for all the variables namely food insecurity (FS), exchange rate (EXCH), inflation rate (INF), and world oil price (WOP).

All the variables have positive mean and medium implying that the variables increased during the sample period on the average. In general, the variance of variables as evidenced by the standard deviation is generally moderate. The skewness of a normally distributed series is zero. All the variables are positively skewed. The kurtosis measures the thickness of the distribution of the series and for a normal distribution, kurtosis is equal 3. The kurtosis for exchange rate, inflation, food insecurity and world oil price have a value above 3 which shows they have a long- right tail and hence leptokurtic. The Jarque-Bera statistic measures the difference between the skewness and the kurtosis of each of the variables from the normally distributed variable. The null hypothesis for the Jarque-Bera test is that the distribution is normal. For all the variables, the null hypothesis of a normal distribution is clearly rejected because the probability values are less than the 0.05% level of significance. The non-normality of the variables would not bias the results in the case of NARDL.

Table 2: Descriptive Statistics of Variables Used

	EXCH	INF	WOP	FS
Mean	80.61	17.69	32.32	10.93
Median	21.89	13.13	24.15	9.05
Maximum	411.50	72.84	91.48	29.40
Minimum	0.42	3.46	3.19	0.70
Std. Dev.	106.08	14.83	24.42	5.58
Skewness	1.35	2.08	1.20	1.74
Kurtosis	4.13	6.88	3.51	6.19
Jarque-Bera	17.30	64.77	11.96	44.59
Prob.	0.00	0.00	0.00	0.00

Source: Authors' Computation

Unit root tests

Table 3 presents the unit root properties of the variables (exchange rate, inflation rate, world oil price and food insecurity) prior to regression using Augmented Dickey – Fuller test (ADF) and Philip Perron (PP) test which test for stationarity or non-stationarity of the variables and the decision is taken based on either the t- statistics or probability (p-values).The ADF and PP test results indicate that all the series except inflation have a unit root. In other words, only inflation is stationary at level, that is order 1(0), the rest variables were not stationary at level but stationary at first difference. The null hypothesis of unit root is rejected for food insecurity, exchange rate and world oil price in level by both ADF and PP unit root tests at 1% level. This implies that food insecurity, exchange rate and world oil price have no unit root (i.e. stationary) in their first difference and are therefore integrated of order one, 1(1). The finding agrees with Nwoko et al. (2016) on the effect of oil price on Nigeria food price volatility who found that all variables were stationary at first difference. Given that our unit root test results reveal a mix of I(0) and I(1) variables, the ARDL-based approach remains the most appropriate estimation technique, as it accommodates variables with different orders of integration without requiring them to be exclusively I(0) or I(1).

Table 3: Unit Root Tests

			ADF Unit Root Test		
Variable	Level		First difference		
	T-Statistic	Probability	T-Statistic	Probability	Decision
EXCH	-1.844	0.667	-6.310***	0.000	1(1)
INF	-4.470***	0.004			1(0)
FOOD INSECURITY	1.457	0.999	-6.772***	0.000	1(1)
WOP					
n = 50	-2.342	0.404	-7.059***	0.000	1(1)
			Phillip-Peron Unit Root Test		
Variable	Level		First difference		
	T-Statistic	Probability	T-Statistic	Probability	Decision
EXCH	-2.039	0.565	-6.302***	0.000	1(1)
INF	-3.818**	0.023			1(0)
FOOD INSECURITY	1.540	0.999	-11.255***	0.000	1(1)
WOP					
n = 50	-2.323	0.413	-7.085***	0.000	1(1)

Source: Author's Computation

***and ** indicate stationarity at 1% and 5% level of significance respectively

Bounds Test for Cointegration between Oil Price Food Insecurity and all its Regressors

Two or more variables are said to be cointegrated if they have long run association. The decision criteria are that once the F-value is lower than the I (0) bound, we cannot reject the null hypothesis of no cointegration but if the F-value is higher than the I (1) bound, we reject the null. The result of the bounds test in Table 4 shows that the computed F statistics 18.382 is larger than the bound upper critical value at all conventional significant levels which indicates the occurrence of long run relationship between oil price and food insecurity. Therefore, we rejected the null hypothesis which states that there is no long run relationship between oil price and food insecurity. This finding agrees with Abdulaziz *et al.* (2019) that there is a long run relationship between oil price and food security.

Table 4: Bounds Test for Cointegration between Oil Price and Food Security

Test statistic	**Value**	**Significance %**	**1 (0)**	**1 (1)**
F	18.382	10	2.200	3.090
		5	2.560	3.490
		1	3.290	4.370

Source: Authors' Computation

Short and Long Run Asymmetric Effects of World Oil Price on Food Insecurity

Table 5 shows the results asymmetric effect of world oil price on food insecurity (undernourishment) in the short and long run. Estimations are based on the Heteroskedasticity and Autocorrelation Consistent (HAC) Newey-West estimator. However, before interpreting the results, the stability tests results are presented in Figures 1 and 2. Both the CUSUM and CUSUM Squared plots show that the NARDL model selected is stable.

The variable of interest in Table 2, world oil price (WOP) is decomposed into positive and negative shocks. The negative shocks (LNWOP_NEG) represent the asymmetric impact of oil price declines, while the positive oil price shocks (LNWOP_POS) represent the impact of rising oil prices. Starting with the long run NARDL results in the upper panel of Table 5, the coefficient of the positive oil price shocks (LNWOP_POS(-1)) 0.021implying that rising oil prices increases food insecurity albeit insignificant. The coefficient of LNWOP_NEG (decrease in world oil prices or negative oil price shock) is negative (-0.592) and significant at 1%. The highly significant negative coefficient for negative changes in world oil prices suggests that a decline in oil prices leads to a rise in food insecurity in the long run since this negative coefficient of LNWOP_NEG in the context of NARDL model indicates an inverse relationship consistent with Shin et al. (2014), Ahmed et al. (2021), Abosedra et al. (2023), and Gyamerah et al. (2024). Falling oil prices hurt oil-exporting economies (like Nigeria), reducing public revenues and weakening food subsidies or rural support. The macroeconomic slowdown triggered by declining oil prices could worsen poverty and access to food. This finding is supported by Baumeister and Peersman (2013) who suggest that in oil-exporting countries, lower oil prices could reduce government revenues, leading to cutbacks in food subsidies and social protection programs, potentially increasing food insecurity for vulnerable populations. This also agrees with Andam *et al.* (2020); Balana *et al.* (2020); and Balana *et al.* (2023) who found that oil price has a significant impact on food security. Conversely, Nazlioglu *et al.* (2013) found that lower oil prices reduce agricultural production costs, leading to lower food prices and improved food security, especially in countries where energy constitutes a large proportion of input costs in agriculture. The evidence supports long-run asymmetry: food insecurity responds more severely to oil price drops than to price increases, likely due to macroeconomic vulnerabilities in oil-dependent economies.

The coefficient of LNEXCH(-1) is -0.231 and significant at 1%, which indicates that an increase in the exchange rate is associated with a significant decrease in food insecurity in the long run. The negative coefficient suggests that as the exchange rate increases (depreciation of the local currency), food insecurity decreases. This might seem counterintuitive because depreciation typically makes imports more expensive, which should lead to higher food prices and thus increased food insecurity, particularly in countries reliant on food imports. However, a possible explanation is that depreciation could stimulate local agricultural exports, improving farm incomes, food availability, and economic conditions, thereby reducing food insecurity domestically. Some studies find similar effects where depreciation in exchange rates boosts local agricultural production by making exports more competitive. For example, Ali and Anwar (2017) found that exchange rate depreciation can improve food security in export-oriented agricultural economies. On the contrary, Swinnen and Squicciarini (2012) show that in many developing countries, a weaker exchange rate tends to increase food prices, leading to higher food insecurity, particularly where food imports form a significant portion of food supply.

The coefficient of LNINF is -1.112 is significant at 1%, showing that inflation also has a significant negative impact on food insecurity in the long run. The negative relationship between inflation and food insecurity here suggests that higher inflation is associated with lower food insecurity. This could reflect an anomaly where inflation, potentially driven by increased food prices or agricultural commodities, boosts rural incomes, particularly in countries where a large proportion of the population is engaged in farming such as in Nigeria. If agricultural producers benefit from higher prices (as long as the increase in input costs does not outpace output prices), inflation may improve their ability to access food, reducing food insecurity in rural areas. Ivanic and Martin (2008) found that agricultural producers in developing countries could benefit from rising food prices driven by inflation, which in turn could reduce food insecurity for producers even if urban consumers face greater food insecurity. In contrast, Timmer (2000) showed that inflation in food prices typically worsens food insecurity, particularly for urban and poor populations, as it erodes purchasing power.

The result of the short run asymmetric effect of oil price on food insecurity (undernourishment) Table is presented in the lower panel of 5. The error correction mechanism (ECM) also called the speed of adjustment is negative (-0.872) and statistically significant at1% level. This suggests that when food insecurity deviates from its long-run equilibrium, it adjusts back towards that equilibrium at a rate of 87.2% of the deviation in the subsequent period. The negative sign indicates that if food insecurity is above its long-run equilibrium, it will decrease, and if it is below, it will increase. This rapid adjustment rate means that the system corrects itself fairly quickly after a shock. Ideally a speed of adjustment of -1 or close to -1 is desirable. The model has a good fit with the value of R^2 of 0.918. This means that 91.8%

of variation in food security is explained by inflation rate, world oil price and exchange rate during the period under review.

The coefficient of change in lagged food security in the first period, D(LNFS(-1)), is negative (-0.106) and statistically significant at 5%. This suggests that high food insecurity in one period tends to be followed by a 0.106% reduction in the next period. This dynamic implies the presence of short-run corrective mechanisms—possibly through emergency interventions, informal coping strategies, or seasonal adjustments.

The effect of change in exchange rate, D(LNEXCH), is negative (-0.506) and statistically significant at 1%. This implies that 1% change (depreciation) in the current value of exchange rate leads to a 0.506% decrease in food insecurity in the short run. This suggests that short-run changes in exchange rates may temporarily benefit food security, possibly due to improved competitiveness of domestic agricultural products. Similar result was found for the third lag.

The coefficient of change in lagged inflation rate, D(LNINF(-1)) is 0.775 and statistically significant at 1%. This implies that a 1% change in the inflation rate from the previous period results in a 0.775% increase in food insecurity in the current period in the short run. This reflects how inflationary pressures, particularly on food prices can quickly erode purchasing power and elevate food insecurity. In the short run, households — particularly low-income or vulnerable ones — are unable to adjust quickly to rising prices (e.g., through wage increases or asset sales). This leads to reduced access to sufficient or nutritious food, increased reliance on coping mechanisms (e.g., skipping meals, reducing diet quality), and ultimately, a higher level of food insecurity.

The short-run effect of positive changes in world oil prices (i.e., oil price increases), D(LNWOP_POS), is positive and marginally significant at the 10% level. This suggests that a 1% increase in world oil prices leads to approximately a 0.194% increase in food insecurity in the short run. Though not strongly significant, this result implies that rising oil prices may temporarily increase food insecurity, possibly through higher transportation and input costs for food production and distribution, increased consumer prices, especially for imported or fuel-intensive food items. The coefficient of D(LNWOP_NEG) is -0.872 and it's significant at 1%. This captures the short-run impact of negative changes in oil prices (i.e., oil price decreases). This implies that a 1% decrease in world oil prices leads to a 0.872% increase in food insecurity in the short run. Although counterintuitive at first glance, this result likely reflects the vulnerability of oil-exporting economies like Nigeria, where a drop in oil prices can sharply reduce government revenue, lead to macroeconomic instability (e.g., cuts in food and fuel subsidies), and consequently cause economic hardship that aggravates food insecurity, especially among the poor. A reduction in oil prices can harm oil-exporting economies, could lead to budget cuts in social programs, including food security initiatives. The coefficient is large and highly significant, implying that a one-period lag of negative oil price changes (falling oil price of decrease in oil price) sharply increases food insecurity. This underscores the adverse effect of falling oil prices on economies dependent on oil revenues, where a decline in income may directly reduce the ability of governments or households to secure food.

Overall, in the short run, the results indicate asymmetric effects of positive and negative changes in world oil prices on food insecurity. The results show short-run asymmetry, food insecurity reacts more strongly and adversely to oil price declines than to increases. While rising oil prices slightly worsen food insecurity, falling oil prices significantly worsen it, likely due to broader macroeconomic vulnerabilities in oil-dependent contexts. These findings disagree with Bakhat and Wurzzburg (2013) and Apergis and Miller (2009) but agrees with the finding of Abdulaziz *et al.* (2019), Nazlioglu et al. (2013), Baumeister and Kilian (2014) and Esmaeili and Shokoohi (2011) that increase in world oil price have significant effect on food security in the short run.

Table 5: The Estimates of Short and Long Asymmetric Effects of World Oil Price on Food Insecurity

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Long Run Estimates:				
LNINF(-1)	-1.112	0.249	-4.468	0.000
LNEXCH(-1)	-0.231	0.041	-5.562	0.000
LNWOP_POS(-1)	0.021	0.054	0.382	0.705
LNWOP_NEG(-1))	-0.592	0.084	-7.023	0.000
C	1.659	0.185	8.952	0.000
Short Run Estimates:				
D(LNFS(-1))	-0.106	0.052	-2.038	0.049

D(LNINF)	-0.243	0.170	-1.430	0.160
D(LNINF(-1))	0.775	0.172	4.510	0.000
D(LNEXCH)	-0.506	0.067	-7.558	0.000
D(LNEXCH(-1))	-0.003	0.062	-0.054	0.957
D(LNWOP_POS)	0.194	0.106	1.838	0.073
D(LNWOP_NEG)	-0.206	0.095	-2.183	0.035
COINTEQ(-1)	-0.872	0.078	-11.227	0.000
R-Square	0.918			

Source: Author's Computation

Note: *, ** and ***, denotes rejection of null hypothesis at 10%, 5% and 1% significant level, respectively

Wald Test for Short and Long Run Asymmetric Effects of Oil Price and Food Insecurity

The presence of short and long run asymmetric effect of oil price on food insecurity is confirmed by the standard test of asymmetry suggested by Shin *et al.* (2014) by applying Wald test as shown in Table 6. These results strongly reject the null hypothesis of symmetry at the 5% significance level across all three dimensions—long run, short run, and jointly. Specifically: the long-run F-statistic (35.507, p = 0.000) and Chi-square statistic provide compelling evidence that positive and negative oil price shocks exert unequal long-term effects on food insecurity. Similarly, the short-run Chi-square (3.967, p = 0.046) and F-statistic also indicate a statistically significant short-run asymmetry. Further, the joint test confirms that the combined short- and long-run responses are non-symmetric and hence the overall relationship is nonlinear and asymmetric, justifying the use of the NARDL framework over a linear ARDL model. These results are further confirmed by the dynamic multiplier presented in Figure 3 as the symmetric line is clearly within the 95% confidence bands for most of the horizons. These findings reinforce that food insecurity in oil-dependent countries is more sensitive to the direction of oil price changes. Policymakers should design differentiated responses to rising versus falling oil prices such as cushioning vulnerable households during oil revenue downturns and reinvesting oil windfalls in food security systems.

Table 6: Wald Test for Short and Long Run Asymmetric Effects of Oil Price on Food Insecurity

Variable	Statistic	Value	Probability
Long-run			
	F-statistic	35.507	0.000
	Chi-square	35.507	0.000
Short-run			
	F-statistic	3.967	0.054
	Chi-square	3.967	0.046
Joint (Long-Run and Short-Run)			
	F-statistic	18.015	0.000
	Chi-square	36.031	0.000

Source: Author's Computation
Note: ***, denote rejection of null hypothesis at 1% significant level

Figure 1: Cusum Plot

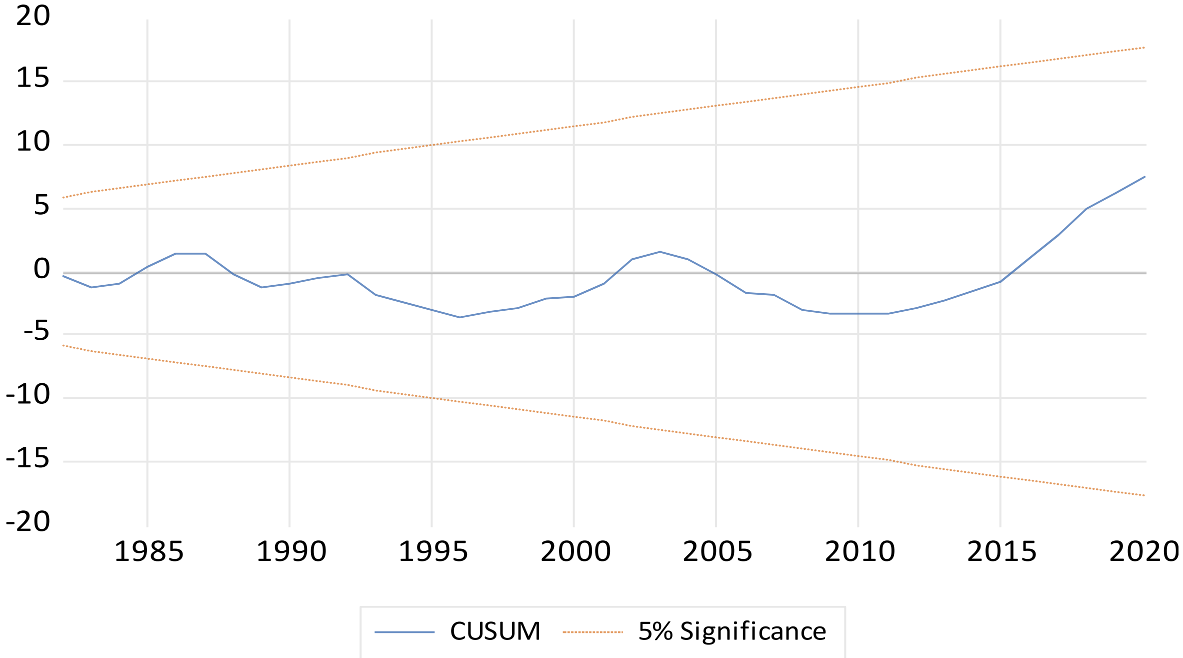


Figure 2: Cusum of Squares Plot

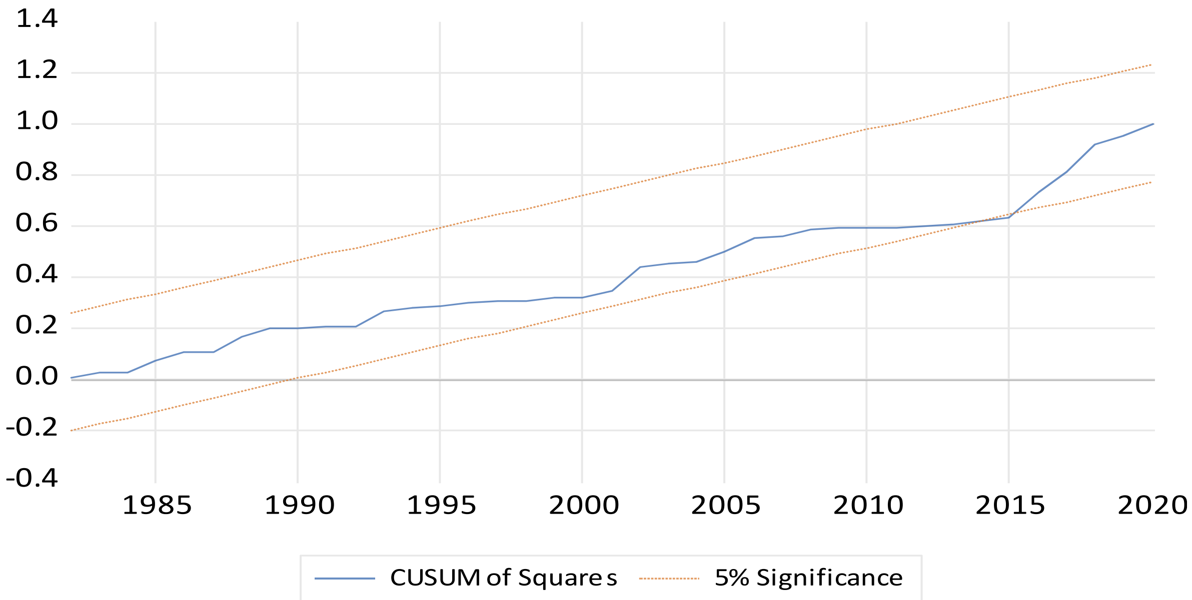
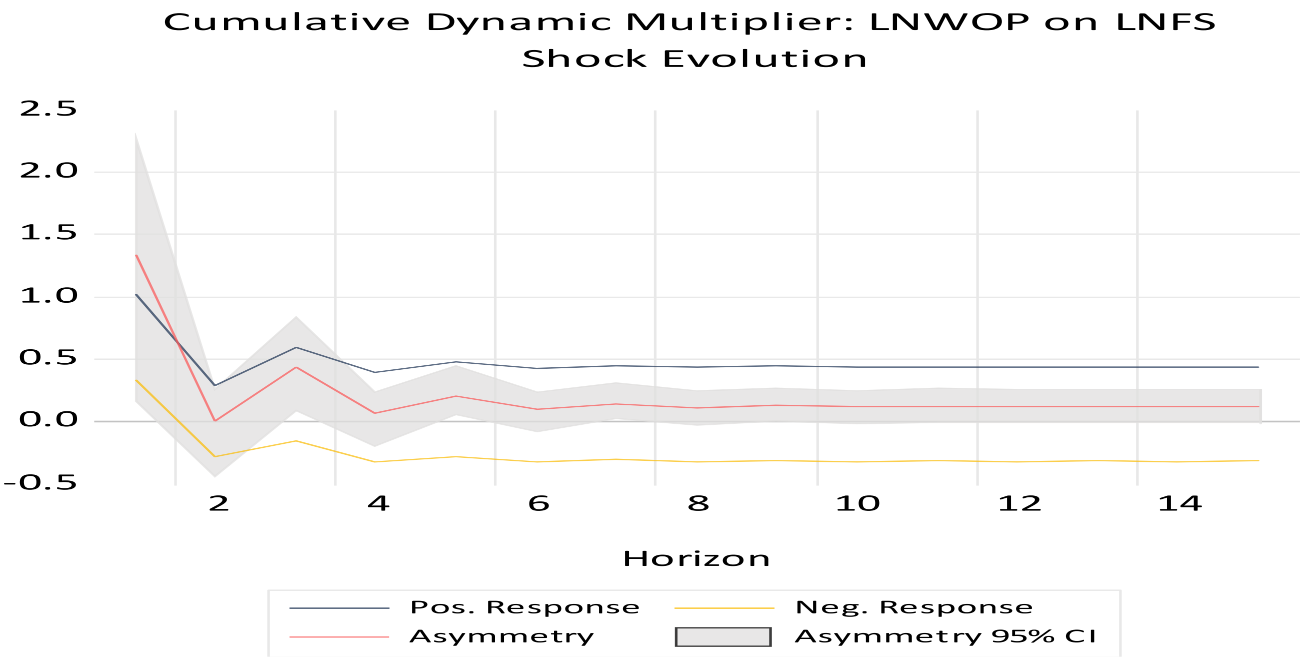


Figure 3: Dynamic Multiplier



5. Conclusion

This study analyzed the asymmetric effects of oil price on food insecurity in Nigeria using the non-Linear autoregressive distributive lag model and time series data covering from 1970 to 2020. This study demonstrates a significant and asymmetric relationship between world oil prices and food insecurity, highlighting both short-run and long-run dynamics. Given the rapid adjustment rate, policy makers need to be cautious in response to oil price shocks as the implications for food insecurity could be severe and immediate. These results underscore the vulnerability of food security systems to fluctuations in oil prices, particularly in regions heavily reliant on oil for economic stability. In the light of these findings, policymakers must adopt proactive and adaptive strategies to mitigate the adverse impacts of oil price volatility on food security. This could include implementing food price stabilization mechanisms, enhancing agricultural productivity through investment in technology and infrastructure, and diversifying energy sources to reduce dependence on oil, diversifying the economies and building buffers (such as sovereign wealth funds) to sustain food security programs during downturns. Additionally, targeted social protection measures may be necessary to support vulnerable populations during periods of oil price surges. The Governments should develop robust social safety nets to shield vulnerable populations from the effects of both positive and negative oil price shocks, particularly focusing on food affordability and availability. Strengthening collaboration between agricultural, energy, and economic sectors can also foster resilience against future shocks, ensuring food security remains a priority in national development agendas. Moreover, supporting domestic production can reduce reliance on imports, lessening vulnerability to exchange rate volatility further; the development of the oil sector should include diversifying into producing relevant input for agriculture. This may include production of agrochemicals such as fertilizer, herbicide, and insecticide among others in order to boost food security in Nigeria. Future studies may explore additional variables or lag structures that may capture the dynamics of food insecurity more effectively.

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Declaration of interest

The authors declare no competing interests.

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