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The Asymmetric Effect of Selected Agricultural Commodities and Oil Prices on Economic Growth in Nigeria

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Abstract. This paper asymmetrically examined the effect of selected commodity prices on Nigeria's economic growth using the Non-linear Autoregressive Distributed Lagged (NARDL) model. Data extracted from the Central Bank of Nigeria's *Statistical Bulletin* covering the period from 2010:1 to 2021:1 were used. We found that the effect of the selected commodities' prices on economic growth is mixed, as some of the selected commodities are positively related to outputs, while some are not. Therefore, the investigation is still open due to the mixed results. This study recommends the sustained support and possible expansion of the agricultural commodities boosting the programme of the Central Government with the adequate monitoring and evaluation of such programmes. Also, the government should tackle the issue of oil importation by developing an adequate refining infrastructure through privatization or public–private partnerships to meet domestic oil demand.

Keywords: asymmetrically, commodities price, economic growth, NARDL

JEL Classification: F43, C24, Q11, Q31

1. Introduction

Economic growth, as measured by the gross domestic product (GDP), is a critical macroeconomic indicator used in capturing many economic indicators about a country such as standard of living and progress in national output, among other things. Modern financial derivatives have become vital in affecting future economic growth by providing global price information, commonly generated from commodity prices (Cheng and Xiong, 2014; Ge and Tang, 2020; Karali and Power, 2013). A commodity is usually an intermediate good. It is mainly consumed for different production processes. We could say it is raw materials for industrial production (Ge and Tang, 2020). Investigating the effect of commodities' prices on economic growth generally reveals a strong impact because of the duality of predicting power embedded in it due to the interaction of the goods and financial market's effect on the commodities market. This assertion is interpreted differently to imply that commodity prices comprise hard and soft data (Ge and Tang, 2020).

The established notion of a positive correlation between commodity prices and economic fluctuations has long been recognized, as commodity price trends typically align with economic cycles, as noted by Fama and French (1988) and Harvey et al. (2017), as cited in Ge and Tang (2020). Events in the crude oil market, coupled with economic realities during specific periods, underscore the significance of commodity prices in influencing economic dynamics. Instances such as the Arab oil embargo in 1970, the Iran–Iraq war in 1980, the Gulf War in 1990, the global financial crisis in 2008, the impact of COVID-19, and the OPEC/Russia price war in 2020, as highlighted by Adeosun et al. (2022), emphasize the non-negligible role of commodity prices in shaping economic outcomes.

In contrast, Borozan and Cipcic (2022) challenged the conventional wisdom put forth by Hamilton (1983), which posits a positive association between outputs and an increase in oil prices. They questioned this notion by asserting that several authors found the lack of a robust relationship between commodity prices and economic growth. Furthermore, Liu and Serletis (2022) corroborated these mixed findings. In their examination of commodity prices and output growth in the G7 and EM7, they obtained varying results, establishing a positive relationship in some economies but not universally across all economies.

Crude oil, constituting approximately 33 percent of the global primary energy and 94 percent of energy utilized in the transport system, holds a significant position among globally traded commodities (Van Eyden et al., 2019, as cited in Adeosun, Tabash, and Anagreh, 2022; Borozan and Cipcic, 2022). Elevated oil prices adversely impact production, leading to increased production costs and subsequently higher prices. The positive impact of a commodity price shock is acknowledged as favourable for exporting nations, while importing economies bear the immediate consequences of price hikes and heightened production costs.

This observation is a widely acknowledged reality in the context of commodity prices, particularly crude oil (Adeosun, Tabash, and Anagreh, 2022). However, the influence of commodity prices, specifically crude oil, on economic growth varies across different economies (Ahmadi and Manera, 2021; Nasir et al., 2019).

As a nation heavily reliant on exports, Nigeria experiences fluctuations in commodity prices. Recognized not only as an exporting country but also as an importing one, Nigeria often imports refined products for its energy needs and processed goods for its agricultural commodities. However, the impact of commodity price fluctuations presents both advantages and disadvantages for exporting and importing countries. In Nigeria's case, the benefits gained from subsidy reform during the decline in oil prices in 2020 were later eroded. The situation worsened for the population within a short period due to a significant positive change in the international oil market, which also affected agricultural commodity prices. Nigeria, maintaining its dual status as both an exporting and importing country, especially in energy commodities, coupled with the fact that existing studies on the effects of commodity prices on economic growth offer mixed findings, and the subject remains open for further exploration, motivates the investigation undertaken in this paper.

This paper employed Non-linear Autoregressive Distributed Lagged (NARDL) model in answering the concern raised therein (Shin, 2014) and in fitting forty-six quarterly time series observations into the model covering the following significant variables: Real Gross Domestic Products (RGDP), Oil Price (OLP), Price of Cocoa (COC), Price of Wheat (WHT), Price of Soybeans (SOY), and Price of Palm Oil (PAL). The explanatory variables are mainly agricultural and energy commodities, explaining the real gross domestic products. The model formation was sequenced to reflect long cycles related to macroeconomic fluctuations as in earlier studies (Aye and Odhiambo, 2021; Igan et al., 2022; Liu and Serletis, 2022; Umaru and Inusa, 2022).

The long-run symmetric ARDL estimation revealed that cocoa and soybean prices exert a positive impact on economic growth. Both the cocoa price (LCOC) and soybean price (LSOY) demonstrated an asymmetric effect on economic outputs, prompting a more comprehensive examination of their long-run effects through a non-linear estimation approach. Employing the non-linear autoregressive model (NARDL) revealed that a positive percentage change in cocoa prices would enhance national outputs by 9 percentage basis points, while an adverse change in the same commodity would decrease output by 14 percentage basis points. Similarly, a positive change in soybean prices would reduce outputs by 15 percentage basis points, whereas a negative change would increase outputs by 43 percentage basis points. Additionally, in short-run asymmetric estimation, a negative change in soybean prices negatively impacted the economy by 53 percentage basis points, and a positive change in palm oil prices equally detrimentally affected the economy by

49 percentage basis points. Conversely, a positive change in cocoa prices boosted economic outputs by 41 percentage basis points. The short-term behaviour of price changes in palm oil exhibited erratic patterns. This study reinforces the dynamic relationship between commodity prices and economic growth in Nigeria during the specified timeframe. It affirms the existence of mixed findings regarding the relationship between commodity prices and economic growth, with certain commodities demonstrating a positive relationship and others exhibiting a negative effect. These effects vary based on the timeframe, the specific commodity, and the economic structure of the economy concerned. Post-diagnostic tests were conducted to ensure the estimates were logical and suitable for policy implications.

The rest of this paper is divided further into four subcategories. First comes the review of the relevant literature, and then the methods are presented – this covers the approach through which the extracted data were analysed. Third are the estimations and results, and fourth are the conclusions and policy implications.

2. Review of the Relevant Literature

Several channels have been considered in explaining the link between commodity prices, especially crude oil prices' economic growth. The most explored are fiscal, exchange rate, wealth, and Dutch disease channels (Hamilton, 1983; Mork, 1989). A positive fluctuation in oil prices hurts disposable income and consumption, and a permanent increment in price hurts private investment (Adeosun, et al., 2022). The impact of commodity prices on growth is ascribed to the part that causes the price change. The causes could be a stronger global demand with attendant higher commodity prices, global under-supply mostly occasioned by the adverse weather effect and geopolitical tension invoking the exporting economies, and stockpiling for precautionary reasons may give credence to the cause (Igan et al., 2022). The first noted cause is effecting higher commodity prices and translating them into an effect on macroeconomic conditions. According to Igan et al. (2022), commodity prices, specifically oil and wheat, have been closely associated with the prices of consumption goods such as premium motor spirit and bread. Also, it turns into a higher cost of production and consequently into the monetary response due to persistent rises in price, thereby slowing economic growth.

Similarly, the cause warrants change in the production pattern and generates economic distortions due to response to its produced dynamics. The effect of the third cause is ambiguous, as the distribution of income increment due to higher prices determines the direction of the effect. Commodity price volatility is, however, an inevitable reality. The changes in commodity prices severely affect emerging countries compared to rich countries, thus inhibiting developing countries' economic growth. The price volatility of the commodity is witnessed in the export revenues associated with natural resources (Jacks et al., 2011). Diversifying from an oil-dependent economy mode is highly encouraged, especially for achieving economic diversification, long-term sustainability, job creation, attracting foreign investment, and addressing environmental concerns (Mensi et al., 2018).

In the pool of exporting/importing commodities, crude oil stands out. It is considered a major commodity in processing all other commodities. Oil is considered pivotal in processing other commodities due to its usage in machinery and as a combustion lubricant for machinery and equipment, special consideration in literature and studies being ascribed to it (Aye and Odhiambo, 2021). There are more studies on the relationship between oil and economic outputs than on any other globally traded commodities featured. However, apart from the three earlier causes, crude oil is a microcosm of the first cause that triggers fluctuation within the fluctuation. Aye and Odhiambo (2021) revealed that there are threshold levels of oil prices at which agricultural growth will start bearing a negative effect of the oil price, though the finding was based on South African data. Empirical investigation from the East African countries affirmed the position of Aye and Odhiambo (2021) when the study posited that global oil prices mainly bore an effect on food prices through transport costs, which was against any other stated factor or cause (Baumeister and Kilian, 2014; Dillon and Barrett, 2016).

The energy and non-energy commodity price trends between 1960 and 2015 showed that both exhibited a similar pattern. Tying the trend became much more feasible in 1980 and was maintained throughout the years. The closeness of the trend started as a result of the price spike in energy commodities in 1973 and 1978, which was intense and long enough for the effect to be feasible. The general downward trend in non-energy commodity prices was equally notable from the mid-1960s until around 2000. In the same vein, a rise in the energy commodity prices again spiked the rise in the non-energy commodity prices and simultaneously fell as a response to the pre-crisis peak of the global economic/financial melt-down in 2008 (Foster-McGregor et al., 2018). Bello and Gidigbi (2022) gave credence to the former assertion when they asserted that low energy prices exhibit a second-round effect on another commodity, with added terms-of-trade changes for several commodity exporters. Two potential scenarios are contemplated regarding the presence of a long-run relationship between oil and non-oil commodities: i) the continued presence of oil rent-seeking strategies and ii) challenges diversifying a country's income (Mensi et al., 2018). Meanwhile, in most developing economies, the second possibility has usually prevailed, i.e. difficulty in maintaining sustainable diversification of the economy.

A different view of the ties between energy and non-energy commodity prices has been related to biodiesel and bioethanol. The validity is challenging because agricultural or non-direct energy commodities, such as corn, compete with crude oil in producing refined products such as diesel and ethanol, which could signal higher prices (Baumeister and Kilian, 2014). The relationship of the energy commodity prices was related to the agricultural products used in energy generation such as corn and soybean (Zafeiriou et al., 2018). Consistent with the study of Zafeiriou et al. (2018), which established a linkage between energy prices and agricultural commodity prices, it implies that outputs slow down if there is a positive change in the energy commodity prices. However, this finding refutes the position of Dillon and Barrett (2016), which empirically revealed that the price effect is mainly a pass-through effect on transport costs. However, Balcilar et al. (2016) had earlier affirmed the relationship between the two and statistically confirmed that oil prices affected agricultural commodity prices; otherwise, it was a decision informed by the methodological approach, which may be misleading. The study employed a linear causality test, which revealed that oil prices did not influence agricultural commodity prices. The study classified the test result as misleading (Balcilar et al., 2016).

Economic outputs have undoubtedly a relationship with commodity prices. It is clear that higher commodity prices have slowed down economic growth. *BIS Bulletin* (54) reported that the price distortion in the form of higher commodity prices in 2022 would result in a decline of 0.7 basic points in the gross domestic products of the advanced economies by the end of 2023 (Igan et al., 2022). Income growth has been identified as a push factor for energy price changes. Oil consumption has increased due to the income increment among the population, especially in China, while income growth regarding agricultural commodities is considered to be mixed and limited (The World Bank, 2014). The strong and sustained economic growth witnessed between 2002 and 2012 is known to be the longest period of demand-driven commodity prices in the last four decades prior to the date concerned.

The rise in commodity prices, particularly evident in the People's Republic of China, is identified as a key factor contributing to the surge during the specified period (Cheng and Xiong, 2014; The World Bank, 2014). This development suggests a potential causality between commodity prices and economic growth. Ge and Tang (2020) delved into the relationship between commodity prices and GDP growth across 27 countries with commonly traded commodity futures indices. Their study categorized commodities into energy, metals, livestock, and agriculture, exploring their effects on consumption growth, government expenditure growth, investment growth, and net export growth. Agricultural commodities yielded a positive coefficient for investment growth and net export growth, while energy showed a negative coefficient for net export growth only. These findings support Nasir et al's (2019) assertion on the varied impact of commodity prices on different economies. Liu and Serletis (2022) investigated commodity price dynamics in G7 and EM7 economies, revealing symmetric weak tail dependence in some countries such as France, Germany, and Japan. Borozan and Cipcic (2022) explored the asymmetric and non-linear impact of oil prices on economic growth in Croatia, finding direct short-run effects.

In Malaysia, Wong and Shamsudin (2017) used a non-linear auto-regressive distributed lag (NARDL) model to examine the impact of crude oil prices, exchange rates, and real GDP on food price fluctuations. They identified a long-run relationship with food prices, where only crude oil prices exhibited a symmetric long-run effect, while real GDP and exchange rates showed asymmetric long- and short-run effects. Gruss (2014) suggested that the commodity price cycle could imply both output growth and lower growth for exporting economies in Latin America and the Caribbean. Cantavella (2020) and Charfeddine and Barkat (2020) conducted studies on oil-exporting economies, highlighting varied responses to oil price shocks and emphasizing the importance of considering specific economic contexts. Charfeddine and Barkat (2020) found short-term asymmetric effects of oil prices on real GDP and economic diversification in an oil-dependent economy, with positive shocks having a more lasting impact on economic activity than negative shocks.

Ahmadi and Manera (2021) studied the impact of oil price shocks on economic growth in developed oil-exporting countries, revealing that the effect depends on the underlying cause of the shocks. Akinsola and Odhiambo (2020) explored the asymmetric effect of oil prices on economic growth in seven low-income oil-importing sub-Saharan African countries, finding a significant negative impact in the long run. Another study in Saudi Arabia by Lianos, Pseiridis, and Tsounis (2023) employed the asymmetric non-linear autoregressive distributed lag (NARDL) model, confirming a long-term relationship between oil and non-oil GDP and suggesting a continued influence of oil rent-seeking strategies on non-oil GDP.

The development was much more pronounced in the People's Republic of China and was the main reason assumed for the surge in commodity prices within the studied period (Cheng and Xiong, 2014; The World Bank, 2014). A posteriori, this is indicative of a possible causality between commodity prices and economic growth.

Ge and Tang (2020) conducted a research on the relationship between commodity prices and GDP growth in nations with 27 widely traded commodity futures indices. They categorized commodities into energy, metals, livestock, and agriculture, examining the impact of each category on consumption growth, government expenditure growth, investment growth, and net export growth. Agricultural commodities produced a positive coefficient for investment growth and net export growth only, whereas energy commodities yielded a negative coefficient for net export growth only. These findings align with Nasir et al's (2019) argument regarding the varying effects of commodity prices across economies. Another investigation into the interplay between commodity prices and economic growth in the G7 and EM7 economies, using a semi-parametric GARCH-in-Mean copula approach, uncovered that certain economies, including France, Germany, and Japan, displayed a symmetric weak tail dependence between commodity prices and outputs (Liu and Serletis, 2022). In Croatia, a study covering the period from 1995:Q1 to 2019:Q4 indicated a positive correlation between commodity prices, especially oil, and economic growth, employing asymmetric and non-linear methodologies. The results supported the notion of asymmetric, non-linear, and direct short-run effects of oil price shocks on real GDP growth (Borozan and Cipcic, 2022).

Moreover, an investigation into the fluctuations in Malaysia's food prices, considering crude oil prices, exchange rates, and real GDP, implemented a non-linear auto-regressive distributed lag (NARDL) model. This study affirms the existence of a long-run relationship with food prices, with only crude oil prices demonstrating a symmetric long-run effect. Conversely, real GDP and exchange rates exhibit asymmetric long- and short-run effects (Wong and Shamsudin, 2017). The research underscores the importance of focusing on exchange rates rather than on crude oil prices in shaping food price policies within the economy. Additionally, a study conducted by Gruss (2014) suggests that the commodity price cycle may signal future output growth for Latin America and the Caribbean but lower growth for the exporting economies in the region. This outcome is contingent on whether the interaction between commodity prices is energy- or non-energy-oriented, leading to a mixed impact on economic growth based on the economic status of the concerned economies.

Building on the outcome of mixed findings, it is evident that oil-exporting economies have shared responses regarding oil price shocks, but the specific impact and resilience vary from one economy to another (Cantavella, 2020; Charfeddine and Barkat, 2020). Charfeddine and Barkat (2020) further explain this relationship by employing the ABSVARX and NARDL models to evaluate the short- and long-term asymmetric effects of oil prices and oil and gas revenue on real GDP and economic diversification in an oil-dependent economy. The study found that both total and non-oil real GDP exhibit more significant responses to negative shocks on oil prices and oil and gas revenues than to positive shocks, indicating an asymmetric impact in the short run. The impact of these shocks, however, is not persistent in the long run. Over the long term, positive oil price shocks and changes in oil and gas revenue exert a more significant influence on economic activity than negative changes, underscoring the resilience of the Qatari economy to adverse shocks.

Ahmadi and Manera (2021) investigated the impact of oil price shocks on economic growth in developed oil-exporting nations, using the threshold structural VAR approach and organizing data into different regimes. They found that the influence of oil price shocks is highly contingent on the root cause of the shocks. Additionally, the study revealed a limited evidence of an asymmetric effect on economic growth. In another study on the asymmetric effect of oil prices on economic growth in seven low-income oil-importing sub-Saharan African countries, employing panel-ARDL and NARDL, it was observed that a positive increase in oil prices significantly hampers economic growth. While the short-term significance of oil price changes on economic growth could not be established, the asymmetric effect was observed to be delayed and confined to the long run (Akinsola and Odhiambo, 2020). Additionally, an investigation into the relationship between oil and non-oil GDP in Saudi Arabia, using the asymmetric non-linear autoregressive distributed lag (NARDL), validates the existence of a long-term relationship. This suggests that Saudi Arabia's non-oil GDP continues to be influenced by oil rent-seeking strategies despite efforts to diversify the economy and reduce reliance on oil. The study proposes a re-evaluation of the subsidy strategy by the government and the allocation of funds to industrial sectors that are more efficient and less dependent on oil.

Furthermore, the government should also consider developing sectors, such as tourism, that are not associated with oil (Mensi et al., 2018). In other words, public investment should be reoriented towards non-oil productive industrial sectors. Similarly, a study on the interaction between oil prices and economic growth in the G7 group, OPEC countries, and including Russia, China, and India revealed that the interaction between changes in oil prices and economic growth could not be established for all the economies considered except for the G7 group, where a unidirectional relation is running from the changes in the oil price towards gross domestic products (Ghalayini, 2011).

In Nigeria, Tumala et al. (2022) studied the commodity and economic growth nexus, but oil was the particular commodity studied. Crude oil prices concerning economic growth were examined using an ADL-MIDAS approach on aggregate and sectoral disaggregated data. Their findings align with conventional commodity prices and economic growth price fluctuation expectations. They recommend adjusting recurrent expenditure in managing the economy during the negative crude oil price fluctuation because of the government involvement in the economy, which is estimated to be at an 80/20 ratio – recurrent to capital expenditure. Also, the study on energy consumption and economic growth in Nigeria with data coverage from 1981 to 2018, using the ARDL approach, described both short- and long-run relationships between the two, among other variables in the study's model. However, the relationship was noted to be statistically insignificant in the short run but significant in the long run. The study concludes that energy consumption dynamically contributed to the output in Nigeria during the period under investigation (Dada, 2018).

3. Methods

This paper used quarterly data to carry out the estimation reported in this study. The data involved forty-six (46) time series observations covering 2010Q1 to 2021Q1. The data were taken from the Central Bank of Nigeria's publication (*Statistical Bulletin*). The sourced data are Real Gross Domestic Products (RGDP), Oil Price (OLP), Price of Cocoa (COC), Price of Wheat (WHT), Price of Soybeans (SOY), and Price of Palm Oil (PAL). RGDP was used to capture economic growth. The price for oil and all other variables are the selected agricultural products as captured in the model of interest to this study.

RGDP was measured in a million naira and as nominal GDP expressed in terms of prices of goods and services. The price of Wheat (WHT), Price of Soybeans (SOY), and Price of Palm Oil (PAL) were measured in US$/Metric ton, the Price of Cocoa (COC) was measured in US$/Ton, while Oil Price (OLP) was measured in US$/barrel of crude oil exports.

Several studies asserted that commodity prices exhibit long cycles and are often related to macroeconomic fluctuations (Aye and Odhiambo, 2021; Igan et al., 2022; Liu and Serletis, 2022). Likewise, oil price relates to macroeconomic fluctuations with attendant effects such as commodity prices. The influence of oil price fluctuation was not limited to the macroeconomics of the energy-exporting country but equally affected the monetary channel (Ahmadi and Manera, 2021). Oil is the most globally traded commodity, with its prices exerting an attendant effect on the global economies (Aye and Odhiambo, 2021). It is clear from the extant studies – some cited herein too – that commodities' prices are related to economic growth.

3.1. Model Specification and Theoretical Expectations of the Parameters

The Non-linear Autoregressive Distributed Lagged (NARDL) model – as informed by the data of interest to the study – was adopted. The model decomposes explanatory variables into positive and negative partial sums for short- and long-run nonlinearities, while asymmetric dynamic multipliers are derived (Shin et al., 2014). NARDL helps circumvent the inherent inadequacies that reside in inferences from either extreme sides (short- or long-run), as the approach is a transverse between the two.

$$\begin{aligned}
\triangle \log RGDP_t = {} & \gamma_0 + \gamma_1 \log RGDP_{t-1} + \gamma_2 \log OLP_{t-1_{P_{t-1}}} + \gamma_3 \log OLP_{t-1_{N_{t-1}}} + \\
& \gamma_4 \log COC_{t-1_{P_{t-1}}} + \gamma_5 COC_{t-1_{N_{t-1}}} + \gamma_6 WHT_{t-1_{P_{t-1}}} + \gamma_7 WHT_{t-1_{N_{t-1}}} + \gamma_8 SOY_{t-1_{P_{t-1}}} + \\
& \gamma_9 SOY_{t-1_{N_{t-1}}} + \gamma_{10} PAL_{t-1_{P_{t-1}}} + \gamma_{11} PAL_{t-1_{N_{t-1}}} + \sum_{k=1}^{n} \gamma_{12} \triangle \log RGDP_{t-1} + \sum_{k=1}^{n} \gamma_{13} \triangle \\
& \log OLP_{P_{t-1}} + \sum_{k=1}^{n} \gamma_{14} \triangle \log OLP_{N_{t-1}} + \sum_{k=1}^{n} \gamma_{15} \triangle \log COC_{P_{t-1}} + \sum_{k=1}^{n} \gamma_{16} \triangle \\
& \log COC_{N_{t-1}} + \sum_{k=1}^{n} \gamma_{17} \triangle \log WHT_{P_{t-1}} + \sum_{k=1}^{n} \gamma_{18} \triangle \log WHT_{N_{t-1}} + \sum_{k=1}^{n} \gamma_{19} \triangle \\
& \log SOY_{P_{t-1}} + \sum_{k=1}^{n} \gamma_{20} \triangle \log SOY_{N_{t-1}} + \sum_{k=1}^{n} \gamma_{21} \triangle \log PAL_{P_{t-1}} + \\
& \sum_{k=1}^{n} \gamma_{22} log PAL_{N_{t-1}} + \tau ECM(-1) + \varepsilon_{t1},
\end{aligned} \tag{3.1}$$

where RGDP is real GDP, OLP is the oil price, COC is the cocoa price, WHT is the wheat price, SOY is the soybean price, and PAL is the palm oil price. Subscript p is positive changes, while N is negative changes. Further, the prefix log indicates the natural logarithm of the variable having it. As associated with variables in the specified model, subscripts p (positive) and n (negative) indicate the decomposition of explanatory variables into positive and negative partial sums in both the short- and long-run respectively. This decomposition has a time dimension as well. The partial sums of the regressor variables' decomposition for the specified model are specified as follows:

$$\{OLP_t^{+,-}\} = \begin{bmatrix} \sum_{j=1}^{t} \Delta OLP_j^P \\ \sum_{j=1}^{t} \Delta OLP_j^N \end{bmatrix} = \begin{bmatrix} \sum_{j=1}^{t} \max(\Delta OLP_j, 0) \\ \sum_{j=1}^{t} \min(\Delta OLP_j, 0) \end{bmatrix} \tag{3.2}$$

A priori, $\gamma_0, \gamma_2, \gamma_4, \gamma_6, \gamma_8, \gamma_{10}, \gamma_{13}, \gamma_{15}, \gamma_{17}, \gamma_{19}, \gamma_{21}$ are expected to exhibit a positive relationship with the regressand in the specified model (eq. (3.1)), while the following parameters are expected to exhibit a negative relationship with the dependent variables: $\gamma_3, \gamma_5, \gamma_7, \gamma_9, \gamma_{11}, \gamma_{14}, \gamma_{16}, \gamma_{18}, \gamma_{20}, \gamma_{22}$.

3.2. Testing for Stationarity

Stationarity testing is an evitable test for time series regressions, as the property is needed to ensure guidance against inefficient estimates, sub-optimal forecasts, and invalid significance tests (Diop and Traoré, 2022). The ideal approach to the stationarity test is to include constant and trend. This general approach is considered in testing the stationarity of the variables captured in the specified model. The general approach model for testing for unit-root is captured thus:

$$\Delta y_t = \beta_0 + \beta_1 t + \rho y_{t-1} + \sum_{i=1}^{\rho} \alpha_i \Delta y_{t-i} + u_t;\ u_t \sim i.i.d\ (0, \sigma_u^2) \tag{3.3}$$

From equation (3.3), if the null hypothesis $\rho = 0$ is rejected by performing a Dickey and Fuller test, γ_t is a stationary process, and it is possible to test the linear trend by performing standard tests. In an instance of non-stationarity of the process, the significance of the trend and the subsequent constant are checked before changing the test integration order. This process is repeated until the stationarity of the variables of interest is achieved, building on and adjusting the standard test as specified in equation (3.3), where y is the variable of interest subjected to a test, followed by intercept, trend, and ρ (stationarity coefficient) being tested.

The Phillip–Perron (PP) unit root test approach estimates the non-augmented DF test equation (3.3) and modifies the t-ratio to avoid disturbance of asymptotic distribution of the statistic due to serial correlation. The PP test, therefore, is based on the following statistic:

$$\tilde{t}_{\alpha} = t_{\alpha}\left(\frac{\gamma_0}{f_0}\right)^{1/2} - \frac{T(f_0-\gamma_0)(se(\hat{\alpha}))}{2f_0^{\frac{1}{2}}3}, \quad (3.4)$$

where $\hat{\alpha}$, t_{α}, and se($\hat{\alpha}$) denote the estimate, standard error, and the t-ratio of α of the test regression respectively. Further, γ_0 is a consistent estimate of the error variance in (3.3), which is calculated as $\frac{(T-k)s^2}{T}$, where k is the number of regressors. f_0 is an estimator of the residual spectrum at frequency zero.

4. Estimations and Results

Table 1 shows the average values for the model series. The statistics showed that the average value for the regressand was far higher than the average values of any other model series. Also, considering the Jarque–Bera statistics and its probability value, it becomes clear that the normality in the model series distribution only holds for RGDP, OLP, and COC. Given the disparity in average values and concerns about normality, it is sufficient to apply natural logarithms on the model series to control for the huge disparity in the average values of the series and the normality distribution of the series, despite the observation size, which satisfies the Central Limit Theorem assumption of normal distribution of series due to the observation size.

Table 1. *Descriptive statistics*

	RGDP	OLP	COC	WHT	SOY	PAL
Mean	16353331	77.26	127.82	106.90	121.08	94.02
Maximum	19550148	120.79	197.39	192.37	264.63	206.06
Minimum	12583478	27.49	75.29	58.00	74.91	54.09
Std. Dev.	1722762	27.68	33.96	26.96	37.72	30.49
Jarque–Bera	0.77	3.56	1.93	7.59	43.77	49.71
Probability	0.68	0.16	0.38	0.02	0.00	0.00
Observations	45	45	45	45	45	45

Source: authors' computation using EViews 11

The correlation analysis reported in *Table 2* showed that all the model series have a fair correlation coefficient with the dependent variable, which is ideal in guiding against multicollinearity. The correlation coefficients concerning the RGDP are not that high to pose a possible multicollinearity problem. However, the oil price produced negative coefficients with all the pair-correlation coefficient results. It more or less exhibits an inverse relationship with all other model series. Also, the degree of association between SOY (the price of soybean) and PAL (the price of palm oil) is high. However, the variable was not dropped from the model series because it has a relatively fair association with all other series. No excessive degree of association is found with any other variables when considering PAL (palm oil price).

Table 2. *Correlation analysis*

Variables	RGDP	OLP	COC	WHT	SOY
OLP	-0.51	1			
COC	0.61	-0.78	1		
WHT	0.33	-0.00	0.41	1	
SOY	0.44	-0.32	0.69	0.85	1
PAL	0.29	-0.29	0.65	0.77	0.94

Source: authors' computation using EViews 11

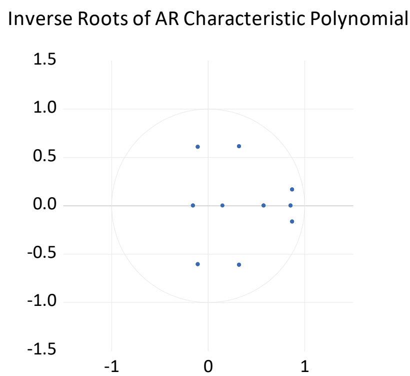
Table 3. *Stationarity test outputs*

	Phillip–Perron (PP)			**Augmented Dicky–Fuller (ADF)**		
	t-stats [Prob. value]			**t-stats [Prob. value]**		
Variables	**At levels**	**At first diff.**	**Order of integration**	**At level**	**At first diff.**	**Order of integration**
LRGDP	-5.21 [0.00]		I(0)	-1.20 [0.89]	-1.91[1] [0.05]	I(1)
LOLP	-2.29 [0.43]	-6.32 [0.00]	I(1)	-2.29 [0.43]	-6.31 [0.00]	I(1)
LCOC	-2.56 [0.29]	-7.56 [0.00]	I(1)	-2.65 [0.25]	-5.62 [0.00]	I(1)
LSOY	-1.35 [0.86]	-4.09 [0.01]	I(1)	-2.00 [0.58]	-4.35 [0.00]	I(1)
LWHT	-1.99 [0.58]	-4.97 [0.00]	I(1)	-1.52 [0.80]	-4.94 [0.00]	I(1)
LPAL	-1.29 [0.87]	-4.36 [0.00]	I(1)	-1.79 [0.69]	-4.40 [0.00]	I(1)

Table 3 shows the results of the stationarity test based on the Phillip–Perron (PP) and the Augmented Dicky–Fuller (ADF) approaches. As stated earlier, the test followed a standard procedure to achieve the series' order of integration. Under the PP, all the series were of induced stationarity at first difference except for the dependent variable (LRGDP), which was stationary at level. Also, the ADF test

1 The estimate here is without constant and trend.

revealed that all the variables are stationary at first difference. However, the trend and constant component of the standard test were dropped for the dependent variable (LRGDP) to achieve its integration at the first difference. Furthermore, the graph in *Figure 1* shows that VAR satisfies the stationarity condition, as no root is located outside the circle. In a nutshell, the model series is stationary.



Source: authors' computation using EViews 11

Figure 1. *Graphical stationarity check*

Model Lag Selections

All the variables in the specified model were included in the test for lag selection, with 43 observations selected. Six statistics presented in *Table 4* were used in the selection of optimal lag for the model of this study. Five of these six tests indicated between lag 2 and 1. LR, FPE, and AIC suggested two lag orders, while SC and HQ favoured one lag order (see *Table 4*). Based on these test results, lag two is considered the upper band of the lag selection, and lag one is considered the lower band lag selection for the model estimations in this paper.

Table 4. *Lag selection*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	89.86	NA	1.33e-08	-3.94	-3.74	-3.87
1	227.69	237.19	7.05e-11	-9.19	-7.96*	-8.74*
2	255.44	41.311*	6.51e-11*	-9.32*	-7.07	-8.49

Source: authors' computation using EViews 11

Note: * Indicates lag order selected by the criterion.

The estimation results presented in *Table 5* encompassed 43 observations, with a lag selection of 2 for the dependent variable, the natural log of RGDP, representing economic growth, and a lag of 1 for WHT (the price of wheat). All other variables were included in the model at the level. The R-square value indicated that the explanatory variables accounted for 72 percent of the total variation in the dependent variable. Adjusting for the explanatory variable would result in a reduction of the R-square to approximately 66 percent. Additionally, the F-statistics, assessing the joint significance of the model series, demonstrated that the variables collectively incorporated in the model are statistically significant. Furthermore, the Durbin–Watson statistic, with a value of 1.95, implies the absence of autocorrelation in the model. Consequently, both economic and statistical insights can be derived from the estimation.

Table 5. *ARDL estimation output for economic growth and the selected commodities*

Regressand	**LRGDP**			
Variables	**Coefficient**	**Abs [Coeff./ LRGDP(-1)]**	**Std. error**	**Prob. value**
LRGDP(-1)	0.27**		0.13	0.04
LRGDP(-2)	-0.45***		0.13	0.00
LOLP	-0.04	0.16	0.04	0.34
LCOC	0.21***	0.77	0.06	0.00
LWHT	-0.21*	0.76	0.11	0.08
LWHT(-1)	0.19**	0.70	0.09	0.05
LSOY	0.35***	1.28	0.11	0.00
LPAL	-0.32***	1.18	0.08	0.00
C	18.55***	66.68	2.56	0.00
R^2	72.24%		F-stat.	11.06***
Adj. R^2	65.70%		DW-stat.	1.95

Source: authors' computation using EViews 11

Notes: ***, **, and * imply statistical significance at 1, 5, and 10 per cent respectively.

The long-run symmetric ARDL estimation indicates that all variables in the model are statistically significant, except for the oil price (LOLP), which bears a negative sign. Among the statistically relevant variables, both lag one and lag two of the dependent variables are significant, but the coefficients are less than one percentage point, with the lag two coefficients being negative. The cocoa price (LCOC) is statistically significant at a 1 per cent significance level and exhibits a positive sign. This variable aligns with theoretical expectations, where a percentage increase in cocoa price leads to a 77 basis point percentage (0.77 per cent) rise in economic outputs. The current year's wheat price shows a significant negative association with outputs, while the price of the previous period demonstrates a positive relationship. Additionally, the soybean price is positively linked to outputs, whereas the palm oil price has a negative association. Among all the regressors, the soybean price has the most substantial impact, showing a 1.28 per cent increase with a percentage increment in soybean price. It is followed by the palm oil price with a 1.18 per cent impact, albeit negatively signed.

The results from the model series estimation, as obtained in this paper, aligned with the position of Nasir et al. (2019), who asserted that commodities' prices have a differential effect across economies. Also, within an economy, the selected commodities behave differently; this aligns with the findings of Ge and Tang (2020).

Table 6 reported the F-bounds test for the level relationships among the model series. The F-bounds estimation returned the F-statistic of 9.17, which is outside the bounds of the asymptotic level relation at 1 per cent for a finite sample at both 45 and 40 observations. Since the F-statistic of 9.17 is greater than the returned statistic at 1 per cent, it implies the rejection of the null hypothesis of no level relationship in the series for both the asymptotic and the finite sample observations. Since the hypothesis is already rejected at level, there is no need to consider the statistics for the relationship at the first difference again.

Table 6. *F-bounds test for levels relationship*

Test statistic	Value	Sig.	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
For estimation in *Table 5*			Asymptotic n = 1000		Finite sample n = 45		Finite sample n = 40	
F-statistic	9.17	10%	2.08	3	2.27	3.29	2.30	3.35
K	5	5%	2.39	3.38	2.69	3.82	2.73	3.92
		2.5%	2.7	3.73	--	--	--	--
		1%	3.06	4.15	3.67	5.01	3.65	5.25

Source: authors' computation using EViews 11

Table 7 shows a short-run symmetry ARDL estimation with the error correction coefficient. The short-run coefficient for wheat price exhibited a negative relationship with the output of 34 basis points. The ECM coefficient indicated correction of price diversion within a quarter, though the coefficient is explosive but statistically significant at a 1 per cent significance level.

The estimation results for both the long- and short-run asymmetric non-linear introgressive distributed lags are reported in *Table 8*. The estimation followed a stepwise regression model with a forward selection method and a p-value forward/backward (0.05/0.5) stopping criterion. The model estimation included 42 observations after adjustment, with 32 search regressors and 12 constantly included regressors. The R-squared of the model estimation showed that the explanatory variables account for 89 per cent variation in the explained variable. Possible series adjustments still account for the explained variable at 84 per cent. The F-statistic of 15.37 and the statistical significance at 1 per cent imply the joint relevance of the model series. Also, the Durbin–Watson statistic indicated a possible absence of autocorrelation in the model estimation.

Table 7. *Short-run ARDL ECM estimation for economic growth and commodities*

Regressand	**D(LRGDP)**			
Variables	**Coefficient**	**Abs[Coeff./ LRGDP (-1)]**	**Std. Error**	**Prob. value**
D(LRGDP (-1))	0.45***		0.11	0.00
D(LWHT)	-0.21***	0.34	0.07	0.00
CointEq (-1) *	-1.17***	0.004	0.13	0.00
R^2	65.51%			
Adj. R^2	63.79%		DW-stat.	1.95

Source: authors' computation using EViews 11

Notes: ***, **, and * imply statistical significance at 1, 5, and 10 per cent respectively. * p-value is incompatible with t-bounds distribution.

In the model series long-run estimation, the first lagged for the explained variable [LRGDP(-1)], negative decomposition of sums of oil price (LOLP_N), both partial decomposition of cocoa prices and soybean prices (LCOC_P, LCOC_N, LSOY_P, and LSOY_N), as well as the constant are the only statistically significant coefficients from the model series estimation. However, the partial decomposition of positive changes in the oil price and negative changes in palm oil price revealed a positive relationship with productivity but was not statistically significant. Meanwhile, the partial decompositions of wheat prices and positive changes in the palm oil price exhibited a negative relationship with the outputs, though not statistically significant. Factually, some of these variables did exhibit erratic behaviour due to the prevailing economic structure in the country.

Concerning the statistically significant variables, the modified coefficients, which are then returned coefficients divided by the coefficient of the first lag of the independent variable, revealed that a negative percentage change in the crude oil price would hurt the economy by 4 percentage basis points. This finding is contrary to the findings of Borozan and Cipcic (2022), Cantavella (2020), Liu and Serletis (2022), Tumala et al. (2022), and Wong and Shamsudin (2017) in being asymmetric but in tandem with Charfeddine and Barkat (2020) in the sense that there is a stronger response to negative shocks on oil prices. A positive percentage change in the price of cocoa will boost the national output by 9 percentage basis points, and a negative change in the same commodity will reduce the output by 14 percentage basis points. A positive change in the price will reduce outputs by 15 percentage basis points, and a negative change will increase the outputs by 43 percentage basis points. This finding is in line with Dada (2018), Gruss (2014), and Tumala et al. (2022). The statistically significant variables discussed here followed a theoretical expectation except for the soybean price, which works reversely. Furthermore, in the short-run asymmetric estimation, a negative change in the soybean price hurts the economy by 53 per cent basis points, and a positive change in the palm oil price equally hurts the economy by 49 per cent basis points.

In comparison, the positive change in the cocoa price boosts economic outputs by 41 percentage basis points. The performance of the price changes in palm oil behaves erratically in the short run, while the other two tally with the general expectation. This behavioural pattern could be attributed to the domestic consumption of the product and its relevance for industrial inputs. There is an interesting dynamic to the partial changes in the prices of these commodities, especially in cocoa and palm oil. We used the term interesting dynamics because a positive change in the prices of the two commodities hurt economic outputs and vice versa. This indicates that the domestic economy thrives on these commodities, and the positive change in price hurts consumption within the economy to the point that it can affect outputs. In contrast, the negative price change has the potential to adjust and expand outputs in the long run.

Table 8. *Asymmetric (NARDL) estimation output for economic growth and commodities*

Regressand variables	**D(LRGDP) Coefficient**	**[Coeff./ LRGDP (-1)]**	**Std. error**	**Prob. value**
LRGDP(-1)	-1.99***		0.14	0.00
LOLP_P(-1)	0.03	-0.02	0.08	0.67
LOLP_N(-1)	0.08**	-0.04	0.03	0.03
LCOC_P(-1)	-0.18**	0.09	0.09	0.05
LCOC_N(-1)	0.28***	-0.14	0.10	0.00
LWHT_P(-1)	-0.00	0.00	0.08	0.99
LWHT_N(-1)	-0.16	0.08	0.11	0.17
LSOY_P(-1)	0.30**	-0.15	0.13	0.03
LSOY_N(-1)	-0.86***	0.43	0.18	0.00
LPAL_P(-1)	-0.03	0.02	0.13	0.79
LPAL_N(-1)	0.31	-0.16	0.19	0.11
C	32.76***		2.44	0.00
DLRGDP(-1)	0.75***		0.10	0.00
DLSOY_N	-0.40**	-0.53	0.16	0.02
DLPAL_P(-2)	-0.37***	-0.49	0.12	0.00
DLCOC_P(-2)	0.30**	0.41	0.13	0.03
R^2	89.86%		F-stat.	15.37***
Adj. R^2	84.01%		DW-stat.	2.72

Source: authors' computation using EViews 11

Notes: ***, **, and * indicate statistical significance at 1, 5, and 10 per cent respectively. P-values and subsequent tests do not account for stepwise selection.

In terms of the price dynamics of soybeans, its behaviour reflects the level of domestic consumption, as the coefficients associated with the variable align with theoretical expectations. The coherence of the variable coefficients suggests that there is a lower level of domestic consumption regarding the commodity, and its industrial utilization is not extensive. Soybeans are predominantly an export-oriented commodity, so a positive price change contributes to improved economic outputs.

Table 9 reported the block examination of the long-run relationship among the model series. F-statistic and chi-square test statistics concurred with a long-run relationship among the model series for the long run. Likewise, for the short-run model series estimation, both F-statistic and chi-square test statistics affirmed the relationship among the model series. Both long- and short-run statistics supported the appropriateness of the pooling together of the model series, and the test statistics are both statistically significant at a 1 per cent significance level.

Table 9. *Wald test for long- and short-run asymmetry (NARDL) estimation*

	Long-run			
	F-stat		Chi-square	
Value	17.54***	Significant	157.89***	Significant
Df	(9, 26)		9	
	Short-run			
Value	24.33***	Significant	72.99***	Significant
Df	(3, 26)		3	

Source: authors' computation using EViews 11

Notes: ***, **, and * indicate statistical significance at 1, 5, and 10 per cent respectively.

Results of the asymmetric long-run Wald test are reported in *Table 10*. The long asymmetry of each regressor in the model is tested with t-statistic, F-statistic, and chi-square. The three tests listed agreed with one another on each of the series tested. The test statistics, which is statistically significant at a 1 per cent significance level for both the cocoa price (LCOC) and the soybean price (LSOY), indicates that both series have an asymmetric effect on the economic outputs and that the long-run effects of both series are better examined using the non-linear estimation approach. Meanwhile, a linear approach would be sufficient in examining the effect of all other series in the model apart from cocoa and soybean prices. The development here backed up the finding of Ahmadi and Manera (2021), who asserted that there is little evidence of asymmetry between the crude oil price and economic outputs. However, contrary to the findings of Akinsola and Odhiambo (2020), Liu and Serletis (2022), and Wong and Shamsudin (2017), crude oil prices could not exhibit a non-linear relationship with the economic outputs.

Table 10. *Wald test for long-run asymmetry*

Variables	LOLP	LCOC	LWHT	LSOY	LPAL
t-stat	-0.50	-3.19***	0.99	5.13***	-1.24
[Prob.]	[0.62]	[0.00]	[0.32]	[0.00]	[0.22]
F-stat.	0.25	10.21***	0.99	26.32***	1.55
[Prob.]	[0.62]	[0.00]	[0.32]	[0.00]	[0.22]
Chi-square	0.25	10.21***	0.99	26.32***	1.55
[Prob.]	[0.61]	[0.00]	[0.31]	[0.00]	[0.21]

Source: authors' computation using EViews 11

Notes: ***, **, and * indicate statistical significance at 1, 5, and 10 per cent respectively.

Post-Estimation Diagnostic Tests

Diagnostic tests after the model estimation, as reported in *Table 11*, indicated the absence of serial correlation in the estimation residual. However, only the F-statistic with a probability value of 0.06 accepted the null hypothesis of no serial correlation up to 2 lags. Similarly, the presence of heteroskedasticity in the series residual was rejected, as the three different test statistics, F-statistic, Obs*R-squared, and Scaled explained SS, accepted the null hypothesis of no heteroskedasticity in the residual in the series. Also, the normality test revealed in *Figure 2* confirmed the normal distribution of the estimation residual, reinforced by the Jarque–Bera statistic of 0.99 and the probability value of 0.60. The three subcategories of the post-estimation diagnostic tests discussed showed that the estimation coefficients are reliable and appropriate for policy inference.

Table 11. *Serial correlation and heteroskedasticity tests*

Breusch–Godfrey Serial Correlation LM Test	H_0:	**No serial correlation at up to 2 lags**		
F-statistic	3.00	Prob. F(2,24)	0.06	Accept the H_o
Obs*R-squared	14.38	Prob. chi-square (2)	0.01	Reject the H_o
Heteroskedasticity test	H_0:	There is no presence of heteroskedasticity in the residual.		
F-statistic	0.90	Prob. F(15,26)	0.57	Accept the H_o
Obs*R-squared	14.38	Prob. chi-square (15)	0.49	Accept the Ho
Scaled explained SS	3.68	Prob. chi-square (15)	0.99	Accept the Ho

Source: authors' computation using EViews 11

Normality Test

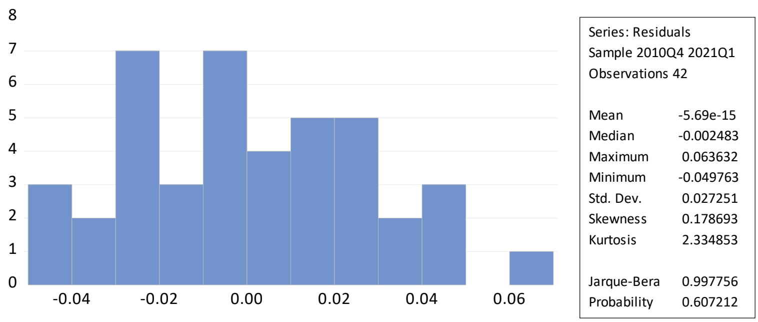


Figure 2. *Normality test for residual distribution*

Stability Tests

The charts in *Figure 3* are graphical stability test results associated with CUSUM and CUSUM square tests. The results in the two figures show stable recursive residuals because the residual line lies within the 5 per cent critical lines, indicating that the parameters in both models are stable. Also, the error variance is stable, as the linear line stays within the critical lines at a 5 per cent level, which equally indicates stable parameters. Thus, both models are reliable and feasible for a policy decision.

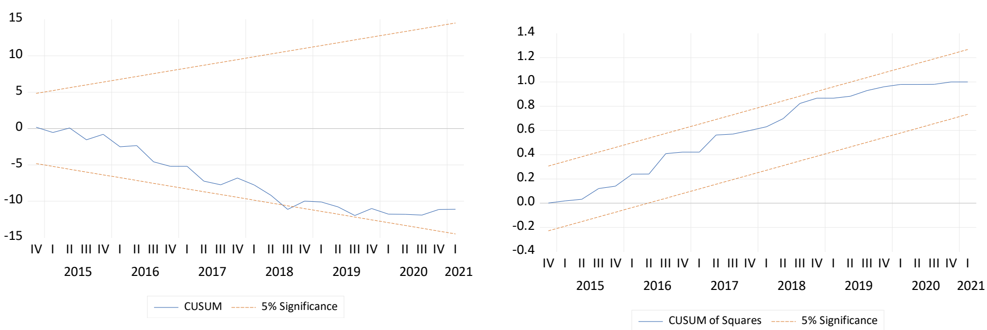


Figure 3. *CUSUM and CUSUM Square charts for Model 1*

5. Conclusion and Policy Implications

This paper asymmetrically examined the effect of selected commodities on Nigeria's economic growth. It used the Non-linear Autoregressive Distributed Lagged (NARDL) model. The estimation followed Shin et al. (2014) by decomposing the variables into positive and negative, which helps in circumventing the inherent inadequacies that reside in inferences from either extreme sides (short- or long-run), as the approach is a transition between the two. The study used data extracted from the Central Bank of Nigeria's *Statistical Bulletin*, covering the period from 2010:1 to 2021:1. We found that the effect of the selected commodities' prices on the economic outputs is mixed, as some of the selected commodities were positively related to output, while some were not. Hence, the further investigation is necessary owing to the inconclusive findings. We found cocoa and soybean prices positively related to the outputs in the long-run symmetric estimation. Cocoa and soybean prices were found to be asymmetrically related to the output, but soybeans exerted a negative effect on the outputs with positive price changes and vice versa. Policy concerning the mass production of soybeans should be promoted and encouraged. Continued FGN support to farmers is favoured, just as a possible expansion to incorporate all areas through which dividends of these agricultural commodities could be fully harnessed. Also, crude oil prices, both negative and positive changes, were negatively related to economic output. The findings suggest a complex scenario in the sector, wherein the country is both exporting and importing concurrently. This complexity has affected the benefits associated with the adverse price change, emphasizing the necessity for a significant shift in deciding whether to function solely as an exporting or importing country rather than maintaining both simultaneously. Establishing a clear national position, whether the country functions as an exporting or importing economy, will aid in assessing the long-term impact of crude oil prices on the Nigerian economy.

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