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ASYMMETRIC IMPACT OF CARBON EMISSION, OIL PRICE SHOCKS ON ECONOMIC GROWTH IN NIGERIA (1981 – 2022)

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ABSTRACT: *The study examines the asymmetric impact of carbon emissions and oil prices on economic growth in Nigeria. The research is conducted using annual time series data running from 1986 to 2019. The study employs Nonlinear autoregressive distributed lag models (NARDL) as the estimation technique. The variables used in the analysis were Gross Domestic Product (GDP), Carbon Emission (CO2), and Oil Price (OP). The NARDL result shows that carbon emission has a negative and significant impact on economic growth in the long run and the oil price has a positive and significant impact on economic growth in both the short-run and long-run. Based on the empirical outcomes of the result obtained, the following recommendations were offered: The implementation of an economic diversification policy from oil reliance towards dependence on other sustainable energy types (renewable energy resources) should be sustained and strengthened especially. The private sector should also tap into the opportunities that are available in the oil sector, such as the decarbonization programme in order to reduce carbon emissions from fossil fuels.*

KEYWORDS: Economic growth; oil price; and carbon emission.

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INTRODUCTION

Background to the Study

The Nigerian economy is characterized by its undersized size; the primary sector accounts for a significant portion of GDP, with agriculture continuing to play a significant role. The oil and gas sector, in particular, is a major driver of the economy, accounting for over 95% of export earnings, roughly 70% of government revenue, and roughly 9.5 percent of GDP as of the first quarter of 2020 (Emachone, 2020).

Additionally, from 1.99 million barrels per day in 2019 (Q4) to 2.07 million barrels per day in 2020 (Q1) to 1.61 million barrels per day in 2021 (Q2), the nation's crude oil production increased (crude oil and condensate production report, 2021). In contrast, as of the first quarter of 2020, the non-oil sector in Nigeria, which includes industry, services, and agriculture, accounted for 60% of government-retained income and 95% of the country's total real GDP (NBS GDP report, 2020 (Q1).

During the oil boom years of 1970 to 1978, Nigeria's GDP rose impressively by 6.2 percent per year (World Economic Situation and Prospect, 2019; Odumusor, 2019). Additionally, as a result of the structural adjustment program (SAP), the GDP increased at a positive rate of 4.0 percent during the decade of 1988–1997, which is known as the period of economic liberalization. The majority of Nigeria's GDP throughout the SAP period was composed of the industrial and manufacturing, agricultural, and oil and gas sectors (Ekpo, 2018).

The global economy is becoming more and more dependent on carbon-intensive energy, thus cutting back on energy use or experiencing a lack of it will have a negative impact on income. Controlling the amount of CO2 emissions may be difficult in oil-producing developing nations where the production and consumption of natural gas and petroleum are important factors driving economic expansion. This is because CO2 emissions may eventually slow down economic growth. According to Awodunmi and Adewuyi (2020), the average natural gas consumption in Algeria, Angola, Egypt, Gabon, and Nigeria increased from around 107.9 billion cubic feet in 1980 to approximately 327 billion cubic feet and 200.79 trillion cubic feet in 2000 and 2018, respectively.

On the other hand, environmentalists generally concur that carbon emissions are positively correlated with output. This suggests that during times of economic growth, emissions have a tendency to rise above trend and to decline when the economy contracts or slows (2014); Khan & Knittel, 2015). Furthermore, compared to output, these emissions are thought to be far more variable and unpredictable.

About 75% of greenhouse gas emissions are attributed to carbon emissions, which have been regarded as a major pollutant (Abbasi & Riaz, 2016; Edoja, Aye, & Abu, 2016). Furthermore, according to the Environmental Kuznets Curve (EKC) Tutulmaz (2015), CO2 is one of the most applied emissions. By definition, the primary cause of an increase in CO2 emissions is the burning of natural gas, coal, and oil for energy purposes, which is the norm in the country under study. In addition, burning wood and waste products, as well as some industrial processes like making

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cement, clothing, alcohol, tobacco, etc., release CO2 emissions into the sky. Thus, environmental harm will rise in tandem with economic activity.

Numerous studies have examined the relationship between energy consumption, carbon emissions, and economic growth throughout the years, but there hasn't been much agreement—as the reviewed works demonstrate. Research has indicated that there is a positive correlation between carbon emissions and oil price shocks in Nigeria. However, another line of research has identified a negative correlation between these factors. Positive relationships between carbon emissions (CO2) and oil price shocks were found by Blazquez, Martin-Moreno, Perez, and Ruiz (2017), Bosah, Ampofo, Asante, Wang, and Li (2020), Chai, Zhou, Liang, Xing, and Lai (2016), and Awodumi and Adewuyi (2020). On the other hand, whereas Aliyu (2009) and Bala and Chin (2018) found in their empirical studies that there is both a positive and negative relationship between carbon emission (CO2) and oil price shock, Nwani, Uwazie, Anochiwa, Onoja, and Ogbonnaya (2019), Mordi and Adebiyi (2011) observed that there is a negative relationship. Furthermore, ARDL (Autoregressive Distributed Lag Model) and NARDL (Non-linear Autoregressive Distributed Lag Model), two strong and dynamic econometrics analysis techniques, are used to investigate the linear and non-linear relationships between the target variable and the policy variables.

Therefore, the primary driving force behind this research is to investigate the asymmetric relationships between the three variables of interest, carbon emissions, economic growth, and the shock to Nigeria's oil price.

EMPIRICAL LITERATURE

Agbanike, Nwani, Uwazie, Anochiwa, Onoja, and Ogbonnaya (2019) examined Oil prices, energy consumption, and carbon dioxide (CO2 emissions: insight into sustainability challenges in Venezuela Between 1971 to 2013, the methodology used is auto-regressive distributed lag (ARDL) and the findings imply that the price of crude oil influences the amount of energy used by the economy. There is no discernible causal link between energy use and economic expansion. In the economy, CO2 emissions are caused by energy consumption. Furthermore, there is a one-way causal relationship between CO2 emissions and economic growth. The way that economic growth reacts to CO2 emissions suggests that higher CO2 emissions would have a detrimental impact on growth.

Akadiri, Bekun, Taheri & Akadiri (2019) examined Carbon emissions, energy consumption, and economic growth: causality evidence between 1972 to 2013, the methodology employed is Autoregressive distributed lag (ARDL), The results suggest a unidirectional causal relationship between carbon emissions and the European Union (EU), as well as between GDP per capita growth and the EU. Nevertheless, there is no causal chain connecting economic development to carbon emissions and the EU. This is in line with the robustness check estimated by the DOLS model, the ARDL estimate, and the estimations of negligible correlation. Iraq's economy is energy

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self-sufficient, as we have confirmed. The long-term, unidirectional causal relationship between growth (output) and the EU supports this.

Awodumi and Adewuyi (2020) examined the role of non-renewable energy consumption in economic growth and carbon emission: evidence from oil-producing economies in Africa 1980–2015, the methodology employed is a nonlinear autoregressive distributed lag (NARDL) model and the results showed that, except Algeria, there was evidence of an uneven relationship between the per capita use of natural gas and petroleum on economic development and carbon emissions. In Nigeria, a positive shift in the amount of non-renewable energy consumed slows growth but lowers emissions. An increase in the use of various energy products in Gabon fosters economic progress and improves the state of the environment. While this energy kind promotes economic progress, its consumption does not affect Egypt's environmental damage. Angola's economy has grown thanks in part to a favourable change in non-renewable energy use, however, the impact on carbon emissions varies depending on the energy source and time of day. Furthermore, the impact of negative changes in natural gas and petroleum consumption is comparable to that of positive changes in Egypt and Nigeria.

Bala and Chin (2018) examined Asymmetric Impacts of Oil Price on Inflation: An Empirical Study of African OPEC Member Countries Between 1995 and 2014, the methodology employed is Autoregressive distributed lag (ARDL), and the outcome showed that inflation was positively impacted by both positive and negative changes in oil prices. The impact was found to be more significant though, when oil prices declined. Additionally, the money supply, exchange rate, and GDP are all positively correlated with inflation, whereas food production is negatively correlated with the impact of oil price volatility on real GDP volatility, with no discernible long-term effect. Other variables' short- and long-term effects on Nigeria's economic cycle (real GDP volatility) do not reach statistical significance. This implies that volatility in oil prices is the primary cause of short-term variations in real GDP. This may be explained by the nation's unstable reliance on oil exports.

Blazquez, Martin-Moreno, Perez, and Ruiz (2017) examined Fossil Fuel Price Shocks and CO2 Emissions: in the Case of Spain between 1969-2013, the methodology employed was Descriptive, and results showed that shocks to the price of oil had a much greater effect on economic volatility. Lastly, considering that different price shocks lead to varying fossil fuel mixes and, consequently, varying CO2 emissions, we evaluate the effect of hydrocarbon price shocks on carbon emissions. Ben, Abayomi, and David (2016) used annual data from 1979 to 2014 to investigate the impact of the oil price shock on Nigeria's macroeconomic performance. The unconstrained Vector Auto Regression model change rate, interest rate, and Nigerian GDP are the methodologies used.

Bosah, Shixiang Lie Ampofo, Asante, and Wang (2020) examined the Nexus between electricity consumption, economic growth, and CO2 Emission: An asymmetric analysis between1971 and 2014, the methodology employed is the Nonlinear ARDL and Nonparametric Causality Approach and the Granger causality test results vary depending on the variable. The outcome offers compelling evidence in favour of the symmetric link between economic growth, carbon emissions, and electric consumption over the long term.

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Chai, Zhou, Liang, Xing and Lai (2016) examined the Impact of International Oil Prices on Energy Conservation and Emission Reduction in China Between 1987 and 2014, the methodology employed the vector autoregressive approach (VAR), and the results showed that for every 1% increase in the price of oil on a global scale, there would be corresponding increases in energy consumption per GDP and carbon dioxide emissions of 0.092% and 0.053%, respectively. When there is high energy consumption and emission, a 1% increase in the price of crude oil globally causes an increase in energy consumption per GDP and carbon dioxide emissions of 0.043% and 0.065%, respectively, over the same period. When energy consumption and emissions are low, a 1% increase in the price of crude oil globally causes a 0.067% increase in energy consumption per GDP unit and a 0.085% drop in carbon dioxide emissions during the same period.

Ekundayo (2016) examines economic growth and carbon emission in Nigeria; the methodology employed is an error correction model and according to the findings, economic expansion has a beneficial effect on carbon emissions during the first phase and a negative influence during the lag period. It also showed that capital investment and trade openness have a beneficial effect on Nigeria's carbon emissions. It is advised that while lowering GDP (in an effort to reduce carbon emissions) may impede the nation's economic development, it is more practical to look for strategies to encourage green growth in the nation.

Malik et al. (2020) examined the Symmetric and asymmetric impact of oil price, FDI, and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach, the symmetric results demonstrate that whereas oil prices increase emissions in the near term and decrease them in the long term, economic expansion and foreign direct investment (FDI) worsen carbon emissions both in the short and long terms. On the other hand, long-term asymmetric results demonstrate that while oil prices grow, they also intensify emissions. The above conclusions are corroborated by the causality analysis.

Matthew, Osabohien, Fasina & Fasina (2018) examine greenhouse gas emissions and health Outcomes in Nigeria, from the period of 1985 to 2016. The methodology employed is the autoregressive distributed lag (ARDL) model. A 1% increase in GHGE is shown to reduce life expectancy by 0.0422%, which is used as a proxy for health outcomes. If this occurs, the mortality rate will inevitably be 146.6%, according to the results of the ARDL econometric approach to co-integration.

Muhammad et. al. (2020) examined the symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. The methodology employed is the ARDL and non-linear ARDL cointegration. The EKC hypothesis for Pakistan was found to be true under both approaches, but symmetric results indicate that FDI and economic expansion exacerbate carbon emissions over the long and short term, while oil prices increase emissions over the short term and decrease them over the long term. On the other hand, long-term asymmetric results demonstrate that while oil prices grow, they also intensify emissions. The causality study reveals a feedback relationship between carbon emissions and economic growth in Pakistan, which validates the aforementioned conclusions.

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Ogundipe (2019) examined CO2 emissions and environmental implications in Nigeria; The study used secondary data from 1970 to 2017 obtained from the World Development Index (WDI) and the methodology employs the Johansen co-integration analysis. According to the findings, the burning of fossil fuels is directly responsible for nearly 80% of Nigeria's carbon emissions. Additionally, it was discovered that during the examined period, pollution increased as income increased and as areas became densely populated.

Okeke (2020) examined the relationship between oil prices and three key macroeconomic variables in Nigeria over the period running from 1960 to 2018 on annualised frequency, with GDP at the centre of focus from a short-run perspective; the methodology used is vector autoregressive model (VAR), the study's conclusions indicate that the value of the Naira tends to rise in tandem with rising oil prices because rising demand for Nigeria's crude oil results in higher oil prices, which in turn generate more foreign exchange needed to balance the country's economy. It was surprising to find that the oil price had a negative and statistically significant impact on the inflation rate (LINF) only at lag 6, indicating that the price of oil did not directly affect the rate of inflation in Nigeria over the following six years.

Omolade, Ngalawa, & Kutu (2019) investigated the influence of crude oil price shocks on the macroeconomic performance of Africa’s oil-producing countries, the study covers the period between 1980 and 2016, which represents the periods with the most boom and doom movements in crude oil prices; the methodology used is a Panel Structural Vector Auto-Regression model, the findings demonstrate that different output responses are given to abrupt rises and decreases in oil prices. Additionally, as both output and investment fall off dramatically, it is seen that structural inflation more closely follows steep drops in oil prices than monetary inflation.

Owan, Ndibe, and Anyanwu (2020) examined the diversification and economic growth in Nigeria (1981–2016): An Econometric Approach Based on Ordinary Least Squares (OLS); the methodology employed is ordinary least square (OLS) and findings c approach of Ordinary Least Squares (OLS) was adopted to empirically analyze the collected data and the findings showed that, throughout the study period, the non-oil gross domestic product had a positive and substantial impact on economic growth, whereas the exchange rate had an inverse but significant impact on economic growth in Nigeria. Nonetheless, non-oil exports and investments had a slight but favourable effect on Nigeria's economic expansion.

Shitile (2020) examined Disaggregated Inflation and Asymmetric Oil Price Pass-through in Nigeria, quarterly data from the period 1996–2019 was used and the methodology employed is a nonlinear autoregressive distributed lag (NARDL) model, according to the findings, following a unitary oil price shock, either positive or negative, it takes 4–8 quarters for the disaggregated inflation to converge to its long-run equilibrium.

Tehranchian and Seyyedkolaee (2017) investigated the impact of oil price volatility on the economic growth in Iran: an application of a threshold regression model; the methodology used is a threshold regression model; the outcome showed that an OPV of 1147.77 serves as a threshold value. Additionally, the impact of OPV on economic growth has declined over time as a result of the coefficient of OPV declining in the second regime relative to the first.

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Theoretical Framework

The environmental Kuznets Curve (EKC) hypothesis serves as the theoretical framework used in this investigation. According to the Environmental Kuznets Curve (EKC) hypothesis, pollution and other forms of environmental degradation increase during the early phases of economic development and decrease during the later stages. This relationship is inverted U-shaped and relates to income per capita. The EKC has the name of the economist Kuznets, who postulated that an inverted U-shaped curve represents the relationship between income and environmental pollution.

The fundamental tenets of EKC are that resource extraction rises in tandem with a nation's industrialisation process, which in turn raises pollution levels. People grow more ready and able to purchase greener energy as their income rises over time and they start to become more aware of environmental quality forcing a subsequent decrease in pollutant emissions after a predetermined amount of time.

The inverted U-shape is achieved in this way. Many academics have interpreted the EKC to mean that developing countries should not attempt to adopt environmental policies; rather, the current environmental issues will be addressed by changes in policy that are adopted later, once those countries become wealthy (e.g. Richmond & Kaufman, 2009). Therefore, it is inferred that developing nations are not doing much in the way of environmental cleanup. However, new research (Dasgupta et al., 2002) shows that developing economies are actually addressing and resolving their pollution issues, which calls into question these beliefs.

Furthermore, contrary to what the EKC hypothesis suggests, the income elasticity of emissions is probably less than 1 but not negative in wealthy nations. The scale effect of rising income per capita on emissions can be countered in slower-growing nations by technical advancements that reduce emissions. Consequently, throughout the past few decades, many nations that are members of the Organization for Economic Cooperation and Development (OECD) have seen significant decreases in emissions per capita. In middle-income countries that are expanding faster than average, the effects of rising income outweigh technology's contribution to lower emissions. Thus, there is a direct correlation between pollution and economic growth.

The connections between these two, however, can be lessened by a number of measures, such as switching to ecologically friendly technology and advancing technological advancements that ensure overall gains in economic production and, more especially, in the reduction of pollution. There might be a limit to how far these connections can be loosened in the future, though, given the pessimism surrounding the possibility of limitless substitution or technical advancement.

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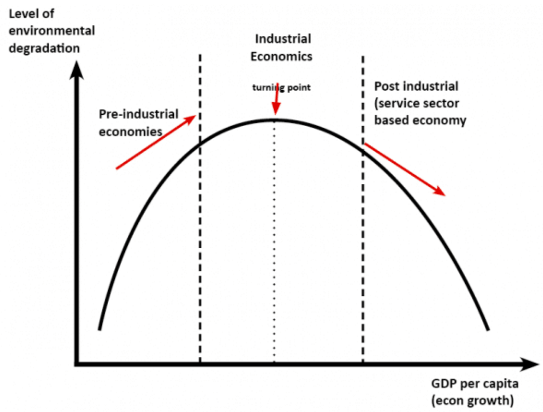

Figure 2.1 Diagram of Kuznets Curve

The Environmental Kuznets Curve is shown in Figure 2.1, with environmental degradation on the vertical axis and per capita income on the horizontal. This data set illustrates the turning point with an inverted U shape. It has also been noted that industrialized nations contract out to developing nations for manufacturing and other activities that result in pollution.

METHODOLOGY

This study uses the ex post facto research design to determine the link between the independent and dependent variables using secondary data. The nature of the study, which exhibits the following traits, makes the ex-post facto research design appropriate. The study spans more than a year, and the non-manipulable data were already available when it was conducted. This study is analytical and uses secondary data to investigate the connection between Nigeria's economic growth, oil price shocks, and carbon emissions.

The purpose of descriptive analysis is to describe the composition and organization of the data. Additionally, correlation analysis is done to look at the inherent relationship between the variables. The short- and long-term effects of the independent variables on the dependent variable were simultaneously investigated using an Autoregressive Distributed Lag Model (ARDL) and a non-linear Autoregressive Distributed Lag Model (NARDL).

This study modified the Bosah, Shixiang Li, Ampofo, Asante, and Wang (2020) model, which examines the relationship between electricity consumption, economic growth, and carbon emission using a nonlinear (asymmetric) approach to determine the short- and long-run asymmetric relationships, in order to critically analyze the relationship between carbon emissions, oil price shocks, and economic growth in Nigeria. The following is the model that the study specified:

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$$logCEi,t = \alpha + \alpha 1 \log ECi,t + \alpha i,t \log EGi,t + \mu i, ----------(3.1)$$

Where;

LOGCE = Log of Carbon Emission

LOGEC = Log of Electric consumption

LOGEG = Log of Economic Growth

The present study modifies the Bosah, Shixiang Li, Ampofo, Asante, and Wang (2020) model by substituting the price of oil for electricity consumption and the gross domestic product for the gross domestic product per capita. Therefore, the model is defined as follows for the investigation of the relationship between carbon emissions, oil prices, and economic growth in Nigeria:

$$GDPPC = \alpha + \beta_1 CO2 + \beta_2 OP + \varepsilon_t \dots \dots \dots \dots \dots \dots (3.2)$$

Where;

GDPPC = Gross Domestic product per capita

CO_2 = Carbon Emission

OP = OIL Price

ε_tDenotes stochastic disturbance term

The *a priori* expectations of the behaviour of the independent variables in terms of their parameters are expected to be positive. We state thu*s;*

To examine the long-term relationship between the variables, this study departs from the widely accepted co-integration methods of Engle and Granger (1987) and Johansen and Juselius (1990) and instead employs a novel and sophisticated method called the autoregressive distributive lag model (ARDL) bounds testing approach, which was created by Pesaran, Shin, and Smith (2001). The reason this strategy has gained popularity recently is that it works well when the variables of interest have a hazy order of integration, such as solely I (0), purely I (1), or I (0) and I (1), which was not the case with earlier methods. Additionally, as Haug (2002) maintains, the ARDL bounds testing approach is more suitable and produces better results for small sample sizes, allowing for the simultaneous estimation of the long-run and short-run parameters. Therefore, equation 3.2's ARDL representation can be shown as follows:

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$$\Delta GDPPC_t = \alpha_0 + \alpha_1 GDPPC_{t-1} + \alpha_2 CO2_{t-1} + \alpha_3 OP_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta GDPPC_{t-i} + \sum_{j=1}^{l} \theta_1 \Delta CO2_{t-j} + \sum_{j=1}^{m} \gamma_1 \Delta OP_{t-j} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3.3)$$

Where; Δ is the first-difference operator and β's andα' show the long-run coefficients and short-run coefficients. Hence, the null hypothesis (H_0) of no cointegration states that:

H_0:$\alpha_1 = \alpha_2 = \alpha_3 = \beta_1 = \theta_1 = \gamma_1 = 0$, and

The alternative hypothesis of the existence of cointegration states that:

H_1:$\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \beta_1 \neq \theta_1 \neq \gamma_1 \neq 0$ respectively.

The aforementioned conjectures are examined through a comparison of the computed F-statistic with critical values derived from Narayan (2005). These values were generated for limited sample sizes ranging from 30 to 80 observations, under the presumption that every variable in the model is I(0) on one side and I(1) on the other. As per standard hypothesis testing procedures, in the event that the computed F-statistic surpasses the upper critical bounds value, we reject H0 and accept H^1. Conversely, if the F-statistic remains within the bounds, the test is deemed inconclusive. Lastly, if the F-statistic falls below the lower critical bounds value, it suggests the absence of co-integration.

Within the context of ECM, causal relationships between variables can be investigated with cointegrated variables (Granger, 1988). The long-term and short-term relationships between the variables are shown here. The model's short-term dynamics are explained by the individual coefficients of the lag terms, while the long-term relationship information is presented by the error correction term (ECT). Similarly, a negative and statistically significant ECT is seen to indicate long-run causation, whereas the importance of the lagged explanatory variable illustrates short-run causality. Equation 3.7 presents the short-run causality model derived from the ARDL model in equation 3.6.

$$\Delta GDPPC_t = \beta_0 + \beta_1 \Delta GDPPC_{t-i} + \beta_2 \Delta CO2_{t-i} + \beta_3 \Delta OP_{t-i} + \mu_t \dots\dots\dots\dots\dots\dots.\dots\dots\dots\dots\dots\dots.. (3.7)$$

While that of the ARDL model in equation 3.7 is presented in equation 3.8; $\Delta GDPPC_t = \beta_0 + \beta_1 \Delta GDPPC_{t-i} + \beta_2 \Delta CO2_{t-i} + \beta_3 \Delta OP_{t-i} + \rho ECM_{t-1} + \mu_t \dots\dots\dots\dots\dots\dots.\dots\dots\dots\dots\dots\dots.. (3.8)$

Where ECM stands for the Error Correction Term (ECT) obtained from the long-run co-integrating relation from the given ARDL models equation 3.8, and Δ is the difference operator. In the long term, causality in equation 3.9 requires ρ to show a negative and substantial sign.

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Finally, the CUSUM of square (CUSUMSQ) and cumulative sum of recursive residuals (CUSUM) tests are used to assess the model's stability. This is based on the claim made by Narayan and Smyth (2005) that Pesaran (1997) recommends using the CUSUM of square (CUSUMSQ) and cumulative sum of recursive residuals (CUSUM) tests to evaluate parameter constancy after the error correction models have been computed.

To elaborate on equation (3.7) and its justification, the NARDL may be understood as an asymmetric extension of ARDL. Consequently, by utilizing the positive and negative partial sum decompositions, an asymmetric co-integration model can be constructed to investigate the asymmetric impacts over both the short and long term. Shin et al. (2014) have indicated that the nonlinear cointegrating regression model can be represented as follows:

$Y_t = \delta^+ X_t^+ + \delta^- X_t^- + \pi_t$………………………………………….. (3.9)

Such that, δ^+ and δ^- represents the associated long-run parameters and X_t is a $k \times 1$ vector of regressors, and it is decomposed as follows;

$X_t = X_0 + X_t^+ + X_t^-$ ……………………………………………… (3.10)

Such that, X_t^+ and X_t^- denote the partial sums of positive and negative changes in X_t as;

$X_t^+ = \Sigma_{i=1}^{t} \Delta X_i^+ = \Sigma_{i=1}^{t} max\ (\Delta X_i, 0)$……………………………. (3.11)

$X_t^- = \Sigma_{i=1}^{t} \Delta X_i^- = \Sigma_{i=1}^{t} min\ (\Delta X_i, 0)$……………………………. (3.12)

In line with Shin *et al.*, (2014), equations (3.11) and (3.12) reveal that the linear ARDL model in equation (3.7) can be modified to show the following nonlinear ARDL model:

$\Delta Y_t = \delta_0 + \delta_1 Y_{t-1} + \delta_2^+ X_{t-1}^+ + \delta_2^- X_{t-1}^- + \sum_{i=1}^{p} \gamma_I \Delta Y_{t-i} + \sum_{j=0}^{q} \vartheta_j^+ \Delta X_{t-1}^+ + \vartheta_j^- \Delta X_{t-1}^- + \varepsilon_t$…. (3.13)

Such that; ε_t is the error term and Δ is the first difference operator, $\vartheta_j^+ = -\varphi\omega_j^+\ and\ \vartheta_j^- = -\varphi\omega_j^-$.

In the NARDL framework, the short-run ($\vartheta_j^+ = \vartheta_j^-$) and long-run (($\delta_1 = \delta_2^+ = \delta_2^-$) asymmetries are examined using the standard Wald test, unlike in the ARDL framework in which the long-run co-movement between the variables is examined by testing the null hypothesis of no co-integration i.e.$\delta_1 = \delta_2^+ = \delta_2^-$. However, the asymmetric cumulative dynamic multiplier effect of a unit change in the decomposed version of the variable X_t i.e $X_t^+$and X_t^- on the target variable Y_t is examined as;

$Z_t^+ = \frac{\sum_{i=0}^{\tau} \beta Y_{t-i}}{\beta X_t^+}, Z_t^- = \frac{\sum_{i=0}^{\tau} \beta Y_{t-i}}{\beta X_t^+}, h = 0, 1, 2$ ………………….. (3.14)

Such that $\tau \longrightarrow \infty,\ Z_\tau^+ = \delta^+$ and $Z_\tau^- = \delta^-$. However, it is worthy of note that δ^+ and δ^- are the asymmetric related long-run parameters which can be measured as $\frac{\alpha_2^+}{\alpha_1}$, and $\frac{\alpha_2^-}{\alpha_1}$ respectively.

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RESULTS AND DISCUSSION

The results of the unit root tests for the variables looked at in this study utilizing the Augmented Dickey-Fuller and Phillip Perron procedures are shown in Table 4.2. To select the suitable analytic technique and prevent a misleading or erroneous regression result, the unit root test basically looks at the stationarity qualities of the variables of interest. The stationary qualities of the variables appear to indicate a mixture of I(0) and I(1) in the table, which supports the applicability of the ARDL bounds technique of the co-integration test in this investigation.

Table 4.2 Unit Root Test Result

Variables	ADF-Statistic	Critical value 5%	Order of integration	PP t-statistics	Critical value 5%	Interpretation
LOG(GDPPC)	-3.602491	-2.954021	I(O)	-3.602491	-2.954021	Stationary Level
D(CO_2)	-5.855832	-2.957110	I(1)	-5.852180	-2.957110	Stationary at 1^{st} difference
D(OP)	-5.035273	-2.957110	I(1)	-4.969662	-2.957110	Stationary at 1^{st} difference

Source: *Authors' Computation from E-views 11, 2023*

The summary of the results of the Augmented Dickey-Fuller and Phillipperon Unit root test is displayed in Table 4.2 above. It displays the degree of variable integration. The Nigerian data from 1986 to 2019 is used to calculate the individual unit root test for stationarity. The table shows that oil prices (OP) and carbon emissions (CO2) are stable at the first difference, but gross domestic product per capita (GDPPC) is stationary at the level.

The Bound Test co-integration analysis result is shown in Table 3. As can be seen from the table, the upper bound critical values at 10%, 5%, 2.5%, and even 1% are not equal to the F-statistic of 12.130930. This outcome indicates that we can move forward with estimating the long- and short-term effect relationships between the target variable and the features in our chosen model. It also validates the presence of a long-term relationship or co-movement among the variables under consideration.

Bounds Test Co-Integration Result

F Test:					
F-statistic	Degree of Freedom	Level of Significance	Pesaran et al., (1999) a I(0) Bound	I(1) Bound	Remark
12.130930	5	10%	3.17	4.14	Co-integrated
		5%	3.79	4.85	
		2.5%	4.41	5.52	
		1%	5.15	6.36	

Source: *Authors' Computation from E-views 11, 2023*

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Estimated Short-run and Long-run Asymmetric ARDL Model

NARDL Long-Run

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2_POS	0.991135	2382.181947	3.236945	0.0230
CO2_NEG	0.140388	4339.385377	4.991984	0.0041
OP_POS	0.063853	28.323659	6.781039	0.0011
OP_NEG	-0.140874	28.513787	-28.096614	0.0000
C	0.218703	2773.564160	2.087285	0.0912

Source: *Authors' Computation from E-views 11, 2023*

NARDL Short- Run

ARDL Cointegrating and Long Run Form NARDL(3, 4, 4, 4, 4) selected based on Akaike info criterion(AIC)				
The dependent variable is LOG(GDPPC)				
Regressors	Coefficients	Std. Error	t- Statistics	Probability
LOG(GDPPC)$_{(t-1)}$	0.323574	0.090733	3.566212	0.0118
D(CO_2^+)	0.393633	0.155414	2.532803	0.0445
D($CO_2^+{}_{(t-1)}$)	-1.595009	0.246417	-6.472792	0.0006
D($CO_2^+{}_{(t-2)}$)	-0.454963	0.225614	-2.016555	0.0903
D($CO_2^+{}_{(t-3)}$)	-0.826606	0.180082	-4.590156	0.0037
D(CO_2^-)	-3.015844	0.506600	-5.953108	0.0010
D($CO_2^-{}_{(t-1)}$)	2.129799	0.556951	3.824034	0.0087
D($CO_2^-{}_{(t-2)}$)	1.061793	0.206108	5.151640	0.0021
D($CO_2^-{}_{(t-3)}$)	0.641545	0.179666	3.570769	0.0118
D(OP^+)	-0.003900	0.002201	-1.772350	0.1267
D($OP^+{}_{(t-1)}$)	-0.001635	0.003526	-0.463684	0.6592
D($OP^+{}_{(t-2)}$)	0.015042	0.003136	4.796639	0.0030
D($OP^+{}_{(t-3)}$)	0.010222	0.002664	3.837456	0.0086
D(OP^-)	0.000661	0.001812	0.365016	0.7276
D($OP^-{}_{(t-2)}$)	-0.010403	0.003133	-3.320921	0.0160
D($OP^-{}_{(t-3)}$)	-0.014726	0.002827	-5.209156	0.0020
ECM(-1)	-0.185209	0.130602	-9.074998	0.0001
R-Square = 0.999826 Adj R-Square = 0.999189 S.E = 0.040290 F- Statistics = 1569.947 Prob(F- Statistics) = 0.000000				

Source: Authors' Computation from E-views 11, 2023

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The outcome of the estimated long-run coefficients of the NARDL model on the correlation between oil price, carbon emissions, and economic growth in Nigeria is shown in Table 4.7. The policy variable, CO2, and the target variable, LOGGDPPC, have an asymmetric connection, meaning that an increase or decrease in carbon emissions will have a significant long-term positive or negative impact on the rate of economic growth. Additionally, there is an asymmetric link between the OP and the goal variable, GDP, meaning that an increase or drop in the price of oil has a major long-term positive or negative impact on the rate of economic growth.

The estimates also show that the partial sum of carbon emissions, or the potential increase or decrease in carbon emissions (CO2+ and CO2-), are not similar in their values and lag lengths, which also indicates asymmetric adjustments of the economic growth rate in the short run. Similarly, the rise and decline in carbon emissions in the short run exhibit an asymmetric inverse relationship with the regress and GDP. Additionally, changes in the price of oil show an asymmetric inverse relationship with GDPPC. The estimations also show that OP+ and OP-have different values and lag times, which suggests that the economic growth rate has been adjusted asymmetrically in the short term.

ARDL Diagnostic Tests

Type	**Diagnostic Test**	**F-stat.**	**Probability**
Breusch-Godfrey LM Test	Serial Correlation	0.084265	0.9194
Breusch-Pagan-Godfrey Test	Heteroskedasticity	1.358496	0.2744
Ramsey RESET Test	Specification	1.151984	0.2953
Jarque-Bera Test	Normality	0.288274	0.865767

Source: *Authors' Computation from E-views 11*

The results of the different diagnostic tests carried out to confirm the accuracy of the regression findings of our dynamic model are shown in Table 4.6. The tests consist of the Jarque-Bera test for normality, the Ramsey RESET test for model specification, the Breusch-Godfrey test for serial correlation, and the Breusch-Pagan-Godfrey test for heteroskedasticity. For each category of diagnostic tests, the F-statistics and probability obtained indicate positivity since they all point to the rejection of the null hypothesis. Explicatively, the serial correlation test result shows the absence of serial correlation as an econometric problem BPG Test shows that the model is not characterized by homoskedasticity, the Ramsey REST Test result justifies the model specification's goodness as previously established, and the Jarque-Bera test shows that the variables are normally distributed given that its probability value is greater than 0.05 or 5% level.

DISCUSSION OF RESULTS

Examining the effects of oil prices and carbon emissions on Nigeria's economic growth is the primary goal of this study. The analysis's conclusions showed that oil prices significantly and favourably affect Nigeria's economic expansion. According to research by Bosah et al. (2020),

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Obi, Awujola, and Oguche (2016), Blazquest et al. (2017), and Ibraheem et al. (2014), oil prices have a positive and significant impact on economic growth. These findings are consistent with the favourable impact of oil prices on economic growth. This means that the price of oil plays a big role in explaining economic expansion.

The ARDL's analysis of the short- and long-term benefits of carbon emissions is consistent with the findings of Agbanike et al. (2019), Adeyemi, Chiamaka, and Oluwatosin (2019), and Stephen (2014), who found that short-term economic growth is positively impacted by carbon emissions. This implies that carbon emissions play a major role in the explanation of economic growth and will, in the near term, have a beneficial effect on it.

The results of the (NARDL) model show that carbon emissions (CO2) have nonlinear impacts on economic growth. Results also show that changes in carbon emissions have a major impact on economic growth both in the short and long term.

RECOMMENDATIONS

The conclusions lead to the following suggestions being made:

i. The adoption of an economic diversification strategy that shifts reliance away from oil and toward other renewable energy sources should be maintained, particularly during spikes in oil prices.

ii. The oil industry offers opportunities that the private sector ought to make use of as well. Since the private sector's involvement will also support the nation's economic development and progress.

iii. Private sector companies whose manufacturing and production processes are directly linked to carbon emissions should fulfil their social obligations by building affordable, well-equipped healthcare facilities or by establishing functional ones in order to reduce the health risks associated with carbon emissions and maintain their beneficial effects on Nigeria's economic growth.

iv. In order to prevent excessive tree burning for wood fuel production, which negatively affects the ozone layer and the environment, the government should also enact regulations in rural areas. However, in order to maintain the positive effects of this practice on Nigeria's economic growth, alternative sources of cooking fuel, such as gas, should be made available to all citizens.

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