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Asymmetric Effects of Crude Oil Price Volatility on Economic Growth in Nigeria: An Empirical Analysis (2000–2023)

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ABSTRACT: This study examines the asymmetric effects of crude oil price volatility on Nigeria's economic growth from 2000 to 2023, using key indicators such as inflation, unemployment, and balance of trade. Employing the NARDL model and supported by various diagnostic tests, the analysis reveals that positive oil price shocks hinder growth, while negative shocks enhance it. Unemployment has a significant negative impact, inflation reduction supports growth, and an improved trade balance boosts GDP. The findings emphasize the need for economic diversification, inflation control, and job creation to achieve sustainable growth.

Keywords: Crude oil price volatility, Economic growth, Inflation, Balance of trade

I. INTRODUCTION

The Nigerian economy is largely dependent on crude oil exports, which makes it highly susceptible to fluctuations in global oil prices. Crude oil has consistently accounted for over 70% of government revenues and 90% of export earnings [1], making price volatility in the oil sector a significant determinant of Nigeria's macroeconomic stability. As oil prices fluctuate due to geopolitical tensions, global demand and supply dynamics, and speculation in the international markets, Nigeria's economic indicators such as GDP growth, inflation, exchange rate, and trade balance experience corresponding volatility.

The persistent volatility in international crude oil prices is attributable to a range of factors, including geopolitical instability, supply-demand mismatches, environmental regulations, and technological advancements. Such fluctuations have exerted considerable pressure on oil-dependent economies, notably Nigeria, which relies predominantly on crude oil exports for domestic revenue mobilization, foreign exchange generation, and overall economic advancement. This pronounced dependence renders the Nigerian economy particularly susceptible to external oil price shocks, with significant implications for its macroeconomic stability.

Although substantial research has examined the impact of crude oil price volatility on economic performance, much of the existing literature tends to focus on isolated macroeconomic indicators such as GDP, inflation, exchange rates, or government revenue. These approaches often overlook the asymmetric and contemporaneous interactions among macroeconomic variables that may be affected by oil price shocks. Empirical evidence indicates that oil price volatility affects several macroeconomic indicators such as employment, inflation, stock markets, and trade balance ([2]; [3]; [4]; [5]; [6]), yet the interconnectedness of these variables warrants deeper investigation to fully understand the broader economic implications.

Existing literature offers limited comprehensive econometric analyses that capture the dynamic interrelationships among multiple macroeconomic variables in the context of oil price volatility. This gap poses a significant challenge for policymakers seeking to formulate informed responses to oil-induced economic disruptions in Nigeria. Accordingly, this study examines the joint and asymmetric effects of crude oil price volatility and selected macroeconomic indicators namely inflation, unemployment, and balance of trade while also exploring their contemporaneous interactions.

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II. LITERATURE REVIEW

A. Global Perspectives on Crude Oil Price Volatility and Economic Growth

Globally, oil price shocks have been widely documented as critical determinants of economic cycles. Hamilton (1983) provided pioneering evidence that oil price increases significantly contributed to U.S. recessions between 1948 and 1980. Building on this, Kilian (2009) differentiated oil supply shocks, aggregate demand shocks, and oil-specific demand shocks, arguing that the economic effects of oil price volatility depend on its source.

Mork (1989) challenged the earlier assumption of symmetry by showing that negative oil price shocks have a more substantial and statistically significant impact on output compared to positive shocks. This finding spurred further research into nonlinear and asymmetric effects, as seen in studies such as Lardic and Mignon (2008), who applied cointegration techniques and confirmed that oil price increases adversely affect output in industrial countries, while oil price decreases had no significant effect.

Similarly, Ratti and Vespignani (2015) examined oil price volatility's impact on investment in oil-importing countries, finding that uncertainty negatively affects capital formation and growth. These insights underscore the importance of asymmetric modeling in understanding the macroeconomic effects of oil price volatility.

B. Empirical Evidence from Sub-Saharan Africa and Nigeria

In the African context, particularly in oil-exporting nations like Nigeria, Ghana, and Angola, oil price volatility has been shown to affect both the real and financial sectors. For Nigeria, where crude oil constitutes over 80% of export revenue and about 50% of government income, price volatility has considerable implications for fiscal stability and macroeconomic performance (Akpan, 2009).

Odusami (2010) employed vector autoregressive (VAR) models to examine the dynamic relationship between oil price shocks and stock market performance in Nigeria, finding significant linkages, particularly during oil booms. Similarly, Iwayemi and Fowowe (2011) employed generalized autoregressive conditional heteroskedasticity (GARCH) models to analyze volatility transmission, concluding that oil price shocks increase macroeconomic uncertainty in Nigeria.

Furthermore, Umar and Abdulhakeem (2010) analyzed the asymmetric impact of oil prices on economic performance using threshold regression models. They found that while oil booms led to increased government spending and temporary growth, oil price declines triggered fiscal crises and contraction, highlighting the importance of nonlinear modeling.

Mogaji (2019) used the nonlinear ARDL (NARDL) approach to investigate the asymmetric effects of oil price changes on inflation in Nigeria, revealing that positive oil price shocks have a larger impact on inflation than negative shocks. This suggests inflation is more sensitive to oil price increases, thereby affecting overall macroeconomic stability.

More recently, Adebayo, Akinsola, and Olayungbo (2021) examined oil price asymmetry and output performance using a combination of NARDL and causality tests. Their study confirmed that Nigeria's economic output responds asymmetrically to oil price changes, and that oil price reductions have a stronger depressive effect on GDP than price increases have a stimulatory effect.

C. Theoretical and Methodological Evolution

From a methodological standpoint, earlier studies used linear VAR and ordinary least squares (OLS) models, which assumed symmetric relationships between oil prices and macroeconomic indicators (Hamilton, 1983; Akpan, 2009). However, these models often failed to capture the dynamic and asymmetric effects of oil price volatility. Consequently, newer studies have adopted nonlinear models, such as NARDL (Shin et al., 2014), threshold autoregressive (TAR) models (Enders & Granger, 1998), and smooth transition models (Granger & Teräsvirta, 1993).

These advanced models allow researchers to test for and estimate asymmetries in both short-run and long-run dynamics. For instance, the NARDL model used by Maji and Sulaiman (2020) to analyze oil price effects on economic growth in Nigeria showed a statistically significant long-run asymmetry, where negative shocks were more detrimental to growth than positive shocks were beneficial.

D. Identified Gaps in the Literature

While significant progress has been made, there remain notable gaps in the literature. First, many studies fail to integrate multiple macroeconomic channels—such as FDI, inflation, exchange rate, and public debt—into a single framework, thereby limiting the understanding of transmission mechanisms. Second, limited studies comprehensively examine the asymmetric impact of oil price volatility on Nigeria's economic growth using recent data that account for policy shifts such

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as fuel subsidy reforms and exchange rate unification policies.

This study aims to fill these gaps by employing a nonlinear modeling framework (NARDL, VECM, Granger causality, and impulse response functions) using data from 2000 to 2023, while integrating multiple mediating macroeconomic variables to better capture the complex interactions between crude oil price volatility and Nigeria's economic growth.

III. MATERIAL AND METHODS

This study adopts an ex-post facto research design, as it relies on secondary time series data that have already been collected and documented. The design is appropriate for investigating the historical relationships between crude oil price volatility and macroeconomic variables without manipulating any data.

To ensure methodological rigor and alignment with the study's objectives, a comprehensive econometric framework was employed. The analysis began with descriptive statistics to examine the distributional properties and general characteristics of the variables, followed by a correlation matrix to explore initial associations among them. To assess the stationarity of the data, both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied.

Subsequently, the Johansen multivariate cointegration test was utilized to determine the presence of long-run equilibrium relationships among the variables. In recognizing potential non-linear dynamics, the Brock-Dechert-Scheinkman (BDS) test for non-linearity was implemented as a preliminary step before estimating the Non-linear Autoregressive Distributed Lag (NARDL) model. This model was selected to capture both short-run and long-run asymmetric effects of oil price volatility on macroeconomic indicators.

Final part for the NARDL is post-estimation diagnostic tests that were performed to validate model reliability and ensure the robustness of the results. Additionally, a granger causality test was conducted to examine dependencies and give insights into the dynamic interactions among the series.

IV. RESULTS

A. Descriptive Statistics

Table 1 below presents summary statistics for the five variables across 96 quarterly observations. The average values suggest a relatively stable macroeconomic environment, with GDP averaging 334.29 and inflation at 13.13%. However, the wide range between minimum and maximum values particularly for the balance of trade (BOT) and GDP reflects considerable fluctuations over the study period.

Table 1: Descriptive Statistic Result

Stats	GDPQ	BOT	INF	UNEM	VOLT
Mean	334.2935	1.839889	13.12699	4.074292	0.084888
Median	378.2565	2.018121	12.79937	3.771234	0.067204
Maximum	580.1027	31.78347	27.69631	5.749469	0.230414
Minimum	68.11570	-26.10920	-1.468097	2.969469	0.011111
Std. Dev.	151.9982	13.22444	4.637542	0.666930	0.058765
Skewness	-0.467751	0.297515	0.197876	1.158357	0.878808
Kurtosis	1.972896	2.689228	4.062568	3.318261	2.943776
Jarque-Bera	7.720430	1.802560	5.142681	21.87383	12.36950
Probability	0.021063	0.406050	0.076433	0.000018	0.002061
Sum	32092.17	176.6294	1260.191	391.1320	8.149243
Sum Sq. Dev.	2194827.	16614.16	2043.146	42.25553	0.328061
Observations	**96**	**96**	**96**	**96**	**96**

Source: Author's Estimation Using E-Views software version 10.

The Jarque-Bera (JB) normality test indicates that only BOT and INF have p-values above the 5% threshold, implying these variables do not significantly deviate from normality. Conversely, GDPQ, UNEM, and VOLT exhibit significant departures from normal distribution, likely driven by oil price shocks and associated macroeconomic volatility.

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Notably, UNEM and VOLT are positively skewed, indicating longer right tails, while GDPQ is negatively skewed. Kurtosis values also suggest light tails for most variables, except INF, which shows signs of leptokurtosis (>3). These distributional features provide one of the justifications for the application of non-linear econometric techniques in subsequent analyses.

B. Correlation Matrix Analysis

The correlation matrix in Table 2 highlights the relationships among the study variables over the 2000–2023 period. Crude oil price volatility (VOLT) is positively correlated with both economic growth (GDPQ, r = 0.63) and unemployment (UNEM, r = 0.69), indicating that oil price fluctuations may be associated with both growth dynamics and labor market instability. Conversely, VOLT exhibits negative correlations with inflation (INF, r = -0.14) and balance of trade (BOT, r = -0.43), suggesting potential destabilizing effects on price levels and external trade performance.

Correlation	GDPQ	BOT	INF	UNEM	VOLT
GDPQ	1.000000				
BOT	-0.517530	1.000000			
INF	-0.114736	-0.262204	1.000000		
UNEM	0.389774	-0.284440	-0.041641	1.000000	
VOLT	0.627256	-0.430655	-0.140543	0.690799	1.000000

Table 2: Correlation matrix

Source: Author's Estimation Using E-Views software version 10.

The negative correlation between GDPQ and BOT (r = -0.52) implies that trade surpluses do not necessarily coincide with output growth, possibly reflecting Nigeria's import dependency for capital goods. Moreover, the relatively low correlations across all variables (none exceeding ±0.8) indicate the absence of multicollinearity concerns, thereby supporting the reliability of regression estimates in subsequent analyses [22].

C. Stationarity Test

Unit root tests indicate that none of the variables are integrated at the second difference. All series achieved stationarity at first difference, except for volatility (VOLT), which is stationary at both level and first difference. Therefore, first-difference results are reported for consistency and model simplicity.

Table 2: First differenced Augmented Dickey-Fuller (ADF) and Philips-Perron Unit Root Test Results

ADF					
Variables	**GDPQ**	**BOT**	**INF**	**UNEM**	**VOLT**
Prob.	0.03	0.00	0.00	0.02	0.00
Status	I(1)	I(1)	I(1)	I(1)	I(1)
Significance	5%	1%	1%	5%	1%
PP					
Variables	**GDPQ**	**BOT**	**INF**	**UNEM**	**VOLT**
Prob.	0.04	0.00	0.00	0.03	0.00
Status	I(1)	I(1)	I(1)	I(1)	I(1)
Significance	5%	1%	1%	5%	1%

D. Lag Selection Criteria

From Table 4 based on the lag selection criteria, the Akaike Information Criterion (AIC), Final Prediction Error (FPE), and Likelihood Ratio (LR) test all suggest using five lags, while the Schwarz Criterion (SC) and Hannan-Quinn (HQ) recommend lag two at the 5% level. To ensure robust and comprehensive estimations, the study adopts the maximum suggested lag (5) and proceeds with model estimation based on the most econometrically appropriate results within the selected lag.

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Table 4: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1091.527	NA	20133.05	24.09950	24.23746	24.15516
1	-429.3578	1237.020	0.016695	10.09578	10.92353	10.42972
2	-294.3232	237.4234	0.001494	7.677434	**9.19498***	**8.28967***
3	-278.5640	25.97675	0.001854	7.880527	10.08788	8.771055
4	-271.7643	10.46107	0.002833	8.280534	11.17768	9.449352
5	-208.5735	**90.2726***	**0.00127***	**7.44117***	11.02812	8.888282

Source: EViews 10

E. Non-Linearity Test Summary

To determine the appropriate modeling approach, the study conducted a BDS test for non-linearity on the series as shown in Table 5.

Table 5: BDS Test for RESID01BOTUNEMINF*VOL

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.169104	0.006605	25.60291	0.0000
3	0.281599	0.010510	26.79234	0.0000
4	0.348496	0.012529	27.81509	0.0000
5	0.384751	0.013071	29.43474	0.0000
6	0.400509	0.012617	31.74297	0.0000

The test results showed statistically significant probability values for the squared residuals of key macroeconomic variables GDP (economic growth), inflation, unemployment, balance of trade, and oil price volatility indicating the presence of non-linear patterns. These findings justify the use of a non-linear ARDL model for subsequent estimations.

F. Non-Linear ARDL (NARDL)

To provide meaningful economic interpretation aligned with theoretical expectations, particularly Okun's Law, this study applies the Non-Linear ARDL (NARDL) model to examine the relationship between crude oil price volatility and key macroeconomic variables. Given constraints such as over-parameterization and matrix singularity, the Okun's focus is placed on two core indicators: economic growth (GDP) and unemployment (UNEM). The study's model captures additional explanatory variables with their positive and negative shocks separately to account for asymmetric effects. This approach, based on [23], is adapted from the framework of [24], as outlined in the model specification below in functional form as:

GDP = f(BOT^-, BOT^+, INF^-, INF^+, $UNEM^-$, $UNEM^+$, $VOLT^-$, $VOLT^+$, C), or the econometric form:

$$GDP = \beta_0 + \beta_1 BOT^- + \beta_2 BOT^+ + \beta_3 INF^- + \beta_4 INF^+ + \beta_5 UNEM^- + \beta_6 UNEM^+ + \beta_7 VOLT^- + \beta_8 VOLT^+ + \mu \quad (1)$$

Finally, the unrestricted Asymmetric ARDL for this study is specified as follows:

Level Equation (Long-Run Relationship):

$$GDP_t=\beta_0+\beta_1 BOT_t^-+\beta_2 BOT_t^+ +\beta_3 INF_t^- +\beta 4 INF_t^+ +\beta_5 UNEM_t^- +\beta_6 UNEM_t^+ +\beta_7 VOLT_t^- +\beta_8 VOLT_t^+ +\mu_t \quad (1)$$

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Dynamic NARDL Representation (with Lags):

$$\Delta GDP_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta GDP_{t-i} + \sum_{j=0}^{q_1} \theta_{1j} \Delta BOT^-_{t-j} + \sum_{j=0}^{q_2} \theta_{2j} \Delta BOT^+_{t-j} + \sum_{k=0}^{q_3} \theta_{3k} \Delta INF^-_{t-k} + \sum_{k=0}^{q_4} \theta_{4k} \Delta INF^+_{t-k}$$

$$+ \sum_{l=0}^{q_5} \theta_{5l} \Delta UNEM^-_{t-l} + \sum_{l=0}^{q_6} \theta_{6l} \Delta UNEM^+_{t-l} + \sum_{m=0}^{q_7} \theta_{7m} \Delta VOLT^-_{t-m} + \sum_{m=0}^{q_8} \theta_{8m} \Delta VOLT^+_{t-m}$$

$$+ \lambda_1 BOT^-_{t-1} + \lambda_2 BOT^+_{t-1} + \lambda_3 INF^-_{t-1} + \lambda_4 INF^+_{t-1} + \lambda_5 UNEM^-_{t-1} + \lambda_6 UNEM^+_{t-1} + \lambda_7 VOLT^-_{t-1} + \lambda_8 VOLT^+_{t-1} + \varepsilon_t \quad (2)$$

Where:
GDP_t = Gross Domestic Product at time t
BOT^+,BOT^- = Positive and Negative changes in Balance of Trade
INF^+,INF^- = Positive and Negative changes in Inflation Rate
$UNEM^+$,$UNEM^-$ = Positive and Negative changes in Unemployment Rate
$VOLT^+$,$VOLT^-$ = Positive and Negative changes in Crude Oil Price Volatility
Δ = First difference operator
Λ = coefficients capture long-run asymmetric relationships
θ = coefficients capture short-run dynamics
εt = White noise error term

Equations (1) and (2) incorporate short-run changes in all decomposed variables (via Δ terms), allowing for the estimation of immediate or transitory effects. It also includes the lagged levels of the decomposed variables to capture long-run adjustment dynamics, while the error correction process ensures that short-run fluctuations are anchored to the underlying long-run relationships.

The presence of asymmetry in both the long-run and short-run equations enhances the model's ability to distinguish between the differential economic impacts of positive versus negative shocks. For instance, a positive oil price shock may affect GDP differently than a negative shock of equal magnitude, a behavior the symmetric ARDL model cannot capture. This feature is particularly critical in policy analysis, where the direction of change is as important as its size.

G. Cointegration Test

In table 6 the bounds test for cointegration confirmed a significant long-run relationship among the variables at the 1% level, with an F-statistic of 8.20. This indicates that crude oil price volatility and the other selected macroeconomic variables jointly move in the long run to influence economic growth. Following the evidence from both the non-linearity and cointegration tests, the study proceeds to assess the asymmetric effects of oil price volatility and key macroeconomic indicators on Nigeria's economic performance. This analysis also tries to assess whether crude oil price volatility has significant impact on economic growth.

Table 6: ARDL Bounds Cointegration Test and Long Run Form

T-Statistics	Value	Sign Level	I(0) Bound	I(1) Bound
F-statistic	8.20885	10%	1.85	2.85
		5%	2.11	3.15
		1%	2.62	3.77***
K (Number of Regressors)	8			

Source: Author's Estimation using E-VIEWS 10. ***, **,* means significance at 1%, 5%, and 10%.

Also, in Table 7 the non-linear ARDL (NARDL) and the specified independent variables (Unemployment, balance of trade and volatility) analysis against economic growth (GDP) were made to explain positive and negative shocks of volatility impact on GDP and GDP-Unemployment connection within the purview of Okun's law.

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Table 7: NARDL Long Run Estimated Results

Variable	Coefficient	t-Statistic	Prob.
BOT_NEG	-4.065093	-4.222493	0.0001***
BOT_POS	5.988260	5.466437	0.0000***
INF_NEG	-6.546494	-3.590556	0.0006***
INF_POS	-3.331720	-1.307526	0.1953
UNEM_NEG	62.38292	2.720644	0.0082***
UNEM_POS	-167.9313	-6.273229	0.0000***
VOLT_NEG	362.9930	1.796517	0.0767*
VOLT_POS	-824.3401	-1.858405	0.0673*
C	113.8384	2.294853	0.0247*
Model Diagnostics			
R^2	0.816		
F-stats (Prob).	0.00		
Durbin-Watson	2.03		

GDP = f(BOT-, BOT+, INF-, INF+, UNEM-, UNEM+, VOLT-, VOLT+, C)

A decrease in crude oil price volatility (VOLT_NEG) helps improve economic growth by 362.99 units. But increase in crude oil price volatility (VOLT_POS) worsens the economic growth by negatively (-824.34) affecting GDP. Thus, there is evidence of adverse effects of increased occurrences of volatility, since crude oil price volatility is not completely control by Nigeria, efforts should be made to reduce over reliance on the oil sector of the Nigerian economy.

Increase in unemployment (UNEM_POS) have negative coefficient (-167.93) or shock to GDP, this conforms to Okun's law, also decrease in unemployment (UNEM_NEG) increase the economic growth. Meaning a decrease in unemployment by 1 unit, increases economic growth by 62.38 units, while an increase in unemployment by 1 unit leads to a greater decrease in economic growth by 167.93 units. The positive and negative responses differ in magnitude and worse is the increase in unemployment given the common social vices it usually carries along the likes of arm robbery, kidnapping and so on, as such, greater efforts should be directed at reducing unemployment.

Reduction in inflation (INF_NEG) helps increase economic growth (GDP), negative shock gives negative coefficient (negative and negative gives positive), while positive inflation shock (INF_POS) coefficient is insignificant. Thus, the ideal policy prescription for better economic performance is to help reduce general prices, this will boost real income and purchasing power in the economy and thereby sending good signal for more production, economic growth and employment in the economy.

An odd result comes from a decrease in balance (BOT_NEG) of trade that give an increase in GDP by -4.06 (negative and negative gives positive), but it is remedied in better magnitude by an increase in balance of trade (BOT_POS) which gives an increase in GDP by 5.99 units, which is more than the -4.06 from the negative shocks. Based on the good outcome of a positive balance of trade, efforts should be made to create an enabling production environment for exports than imports, this will help give balance of trade a more positive outcome.

H. NARDL Post estimation diagnostics

From Table 8, the model is adequate for policy recommendation based on its ability to pass the post estimation diagnostics. It shows no serial correlation, no heteroskedasticity, the specification is correct, and the model is stable via cusum5% bounds. Though the residuals from the NARDL model did not initially meet the normality assumption, the same specification was re-estimated using the Dynamic Ordinary Least Squares (DOLS) method to validate the results. DOLS, known for its ability to correct residual non-normality in cointegrating regressions, confirmed the normal distribution of residuals, thereby strengthening the robustness of the model.

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Table 8: NARDL Model Diagnostics

Variables	**F-Version**	**Chi-Square Version**
Serial correlation (Breusch-Godfrey LM Test)	0.6522	0.5629
Heteroskedasticity (Breusch-Pagan-Godfrey)	0.1350	0.1516
Specification Test (Ramsey-Reset)	0.5168	
Stability test (Cusum test)	Stable within 5% bounds	Stable within 5% bounds
Normality (Jarque-Bera) / DOLS JB	0.0000/ 0.3873	

I. Granger Causality Test

The granger causality test first proposed by [25] is applied to achieve the said objective. In this context, the study investigates the causal relationship between crude oil price volatility and selected macroeconomic variables using the Granger causality test. This analysis aims to determine whether crude oil price volatility has a unidirectional (one-way), bidirectional (two-way), or no causal (neutral) relationship with the macroeconomic variables included in the model as shown in Table 9.

Table 9: Pairwise Granger Causality Analysis

Null Hypothesis:	Prob.	Decision at 5% significance	Nature of causality & hypothesis
BOT does not Granger Cause GDPQ	0.0058	Reject	Uni-directional causality from balance of trade to GDP.
GDPQ does not Granger Cause BOT	0.1839	Accept	
INF does not Granger Cause GDPQ	0.0086	Reject	Uni-directional causality from inflation to GDP.
GDPQ does not Granger Cause INF	0.3056	Accept	
VOLT does not Granger Cause GDPQ	0.0207	Reject	Bi-directional causality between volatility and GDP.
GDPQ does not Granger Cause VOLT	0.0048	Reject	
UNEM does not Granger Cause INF	0.8926	Accept	Uni-directional causality from inflation to unemployment.
INF does not Granger Cause UNEM	0.0002	Reject	
VOLT does not Granger Cause INF	0.0606	Accept	Uni-directional causality from inflation to volatility.
INF does not Granger Cause VOLT	0.0274	Reject	

At the 5% level, volatility and economic growth exhibit bidirectional causality. Inflation and balance of trade significantly Granger-cause GDP at the 1% level, indicating unidirectional causality. These results support the study's second objective by confirming causal links among crude oil price

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volatility, inflation, unemployment, and trade balance.

V. DISCUSSIONS OF RESULTS

The results from the NARDL long-run estimation reveal important asymmetric effects. Positive shocks in crude oil price volatility (VOLT_POS) have a significantly negative effect on GDP (-824.34), while negative shocks (VOLT_NEG) lead to a positive improvement in GDP (362.99). This asymmetry suggests that Nigeria's economy is more adversely affected by increases in oil price volatility than it benefits from reductions, underscoring the need to diversify the economy and reduce reliance on oil revenues. Similarly, the unemployment variable behaves in line with Okun's law: a decrease in unemployment (UNEM_NEG) enhances GDP by 62.38 units, while an increase in unemployment (UNEM_POS) reduces GDP by 167.93 units. This reinforces the economic and social imperative of job creation.

Inflation exhibits asymmetric effects as well. A decrease in inflation (INF_NEG) contributes positively to economic growth, while an increase (INF_POS) is statistically insignificant. This outcome implies that inflation control is crucial for sustaining economic growth, and that policy measures aimed at reducing inflation can yield significant economic benefits. The balance of trade also shows asymmetric effects, where a positive shock (BOT_POS) enhances GDP by 5.99 units, while a negative shock (BOT_NEG) still results in a positive GDP effect of 4.06 units, albeit smaller. This suggests that although Nigeria can withstand negative trade shocks to a degree, greater emphasis should be placed on boosting exports and improving trade balances through industrial and trade policy reforms.

Post-estimation diagnostic tests affirm the robustness of the NARDL model. There is no evidence of serial correlation or heteroskedasticity, the model is correctly specified per the Ramsey RESET test, and the CUSUM stability test confirms parameter stability within 5% bounds. While the residuals initially failed the Jarque-Bera normality test, this limitation was addressed through a re-estimation using Dynamic Ordinary Least Squares (DOLS), which validated the results by correcting for non-normality. Hence, the final model is reliable for policy interpretation and recommendations.

VI. CONCLUSIONS

Given the study's findings on the adverse impact of crude oil price volatility on Nigeria's economic growth, the following policy recommendations are proposed:

Diversification of the Economy: To mitigate the negative effects of crude oil price volatility, it is crucial to reduce Nigeria's over-reliance on the oil sector. Policymakers should intensify efforts toward economic diversification by promoting sectors such as agriculture, manufacturing, and non-oil exports.

Strengthening Employment and Trade Balance: Employment-generating policies should be prioritized to cushion the economic effects of volatility. Improving the trade balance through increased exports can serve as a buffer against external shocks. Strategic investment in trade infrastructure and export-driven industries is essential to enhance international competitiveness and earnings.

Infrastructure and Enabling Environment: Government should focus on providing enabling infrastructure to support sustainable growth across non-oil sectors. Improved infrastructure will foster private sector participation, stimulate productivity, and reduce unemployment, which in turn positively influences economic growth.

Inflation Management: The causal link between oil price volatility, inflation, and economic growth underscores the need for sound macroeconomic management. Policies aimed at stabilizing prices such as effective monetary and fiscal coordination will enhance real income and boost purchasing power, thereby supporting domestic demand and economic expansion.

Export-Oriented Industrial Policy: As a positive balance of trade contributes to economic growth, emphasis should be placed on creating a conducive environment for production and exports. Incentives for export-oriented businesses and reduction of import dependency will help sustain trade surpluses and improve macroeconomic stability.

In summary, a coordinated policy mix targeting diversification, employment, price stability, and trade enhancement is vital for mitigating the adverse impacts of crude oil price volatility and fostering sustainable economic growth in Nigeria.

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