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Crude Oil Price Volatility and its Impact on Nigeria's Balance of Trade: An Empirical Assessment (2000–2023)

Adaji Obaje[1]; Barisua F. Nwinee[2]; Dennis B. Eme[3]

[1] Emerald Energy Institute, University of Port Harcourt, Nigeria
[2] Department of Finance/Banking, University of Port Harcourt, Nigeria
[3] Department of Civil and Environmental Management, University of Port Harcourt, Nigeria

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Abstract: This study investigates the impact of crude oil price volatility on Nigeria's balance of trade from 2000 to 2023, incorporating the Consumer Price Index (CPI) as a moderating variable to capture inflationary dynamics. Using quarterly time-series data, the study explores both the direct effect of oil price volatility and the moderating influence of domestic price levels on trade performance. Preliminary tests confirm stationarity of the variables at I(1), allowing for the application of a cointegrating regression framework. Although the initial econometric model satisfied all diagnostic tests—including serial correlation, heteroskedasticity, and stability tests, the residuals failed the normality assumption. Consequently, the Dynamic Ordinary Least Squares (DOLS) technique was employed to obtain robust long-run estimates, given its efficiency in addressing endogeneity and serial correlation in small sample sizes. Empirical findings reveal a significant long-run relationship between crude oil price volatility and the balance of trade, with CPI playing a moderating role by amplifying the trade imbalance in periods of rising domestic prices. The study highlights the dual vulnerability of oil-dependent economies like Nigeria to both external price shocks and internal inflationary pressures. Policy implications emphasize the need for trade diversification, macroeconomic stabilization mechanisms, and inflation-targeted monetary policies to cushion the adverse effects of oil price fluctuations on trade outcomes.

Keywords: *Crude Oil Price Volatility, Balance of Trade, Nigeria, ARDL, Dynamic Ordinary Least Squares (DOLS), Consumer Price Index (CPI), Macroeconomic Stability, Economic Diversification.*

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I. INTRODUCTION

Nigeria, as a leading oil-exporting nation, has historically experienced fluctuating economic performance due to crude oil price volatility. The country's trade balance, heavily dependent on crude oil exports, faces significant risks when oil prices decline [1]. This study investigates the extent to which crude oil price fluctuations impact Nigeria's balance of trade, exploring both short- and long-term relationships through empirical analysis.

Oil price shocks can arise from various global events, including geopolitical tensions, changes in production quotas by OPEC, and fluctuations in global demand and supply. Nigeria's economic reliance on crude oil revenue exacerbates its exposure to these shocks, leading to foreign exchange instability, fiscal imbalances, and trade deficits during periods of declining oil prices [2]. This research highlights the historical trends of oil price volatility and its corresponding effects on Nigeria's balance of trade.

II. LITERATURE REVIEW

- *Conceptual and Theoretical Framework*

Crude oil price volatility plays a crucial role in shaping Nigeria's economic stability, particularly its balance of trade (BOT) [3]. As a country heavily reliant on crude oil as its primary export, fluctuations in global oil prices directly impact foreign exchange earnings, government revenue, and trade performance.

This study defines oil price volatility as the unpredictable fluctuations in oil prices caused by geopolitical tensions, supply-demand imbalances, speculative activities, and broader macroeconomic uncertainties. The BOT, a key component of the current account in the balance of payments, measures the difference between a country's export and import values. Given that petroleum exports constitute over 90% of Nigeria's total export revenue, BOT is highly sensitive to oil price shocks [4]. The effects of these fluctuations are transmitted through exchange rate movements, inflation, import costs, and foreign direct

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investment (FDI). A decline in oil prices reduces government revenue, depreciates the local currency, raises import costs, and leads to trade deficits [5]. Conversely, rising oil prices boost export earnings and improve the trade balance. However, these gains are often undermined by structural challenges such as low export diversification and poor economic management [6].

Several economic theories help explain the relationship between oil price volatility and Nigeria's BOT. The Balance of Payments (BOP) Theory highlights how oil price fluctuations influence foreign exchange reserves and trade stability [7]. The Dutch Disease Hypothesis explains how high oil prices cause currency appreciation, reducing the competitiveness of non-oil exports and increasing dependency on oil revenue [8]. The Terms of Trade (TOT) Theory illustrates how shifts in oil prices alter the ratio of export to import prices, affecting the country's trade balance [9]. Additionally, the Purchasing Power Parity (PPP) Theory suggests that exchange rate fluctuations adjust over time to maintain trade equilibrium, but in Nigeria's case, sharp declines in oil prices lead to currency depreciation and trade deficits [10]. Lastly, the Structuralist Theory of Trade Balance argues that external shocks, such as oil price volatility, have a more significant impact on economies with weak export diversification [11].

Since Nigeria remains dependent on crude oil exports, external price shocks directly affect its BOT, contributing to economic instability [12]. Without proactive policies aimed at diversifying the economy and stabilizing the trade balance, the country will remain vulnerable to oil price fluctuations and their adverse effects on long-term economic growth.

➢ *Empirical Review*

Empirical research on the relationship between crude oil price volatility and Nigeria's balance of trade (BOT) has provided critical insights into how oil price fluctuations affect foreign exchange earnings, trade performance, and overall macroeconomic stability. However, these studies also exhibit gaps and areas for further research, particularly in addressing policy responses and structural weaknesses in Nigeria's trade system.

Olomola and Adejumo (2006) employed a vector autoregression (VAR) model to examine the impact of oil price shocks on Nigeria's macroeconomic performance. Their findings revealed that oil price increases enhance trade balance due to higher foreign exchange earnings, while declines in oil prices lead to trade deficits. The study provided empirical evidence linking oil price fluctuations to Nigeria's BOT, highlighting the direct effects of oil price shocks on trade performance. However, it did not account for non-oil exports and other external factors influencing the trade balance. Future studies should incorporate structural breaks and examine the role of economic diversification in mitigating oil price shocks.

Similarly, Adeniyi, Abiodun, and Abiola (2021) utilized wavelet analysis to assess the long-run and short-run effects of oil price volatility on Nigeria's BOT. Their findings indicated that trade balance deteriorates significantly during oil price crashes but improves during price surges. This study introduced a time-frequency approach (wavelet analysis) to understand the dynamic relationship between oil prices and trade balance over different time horizons. However, the study failed to incorporate policy responses and fiscal adjustments to oil price fluctuations. Further research should explore how government interventions, such as foreign exchange controls and fiscal policies, impact BOT dynamics.

Jimoh and Olayemi (2019) applied a non-linear autoregressive distributed lag (NARDL) model to analyze asymmetric effects of oil price shocks on Nigeria's trade balance. Their study found that negative oil price shocks have a more severe impact on trade deficits than positive shocks have on surpluses, suggesting that Nigeria struggles to leverage oil booms effectively. This study highlighted the asymmetric nature of oil price shocks, showing that Nigeria's economy lacks the resilience to fully capitalize on oil price increases. However, the research did not examine sectoral contributions to the trade balance beyond crude oil. Future studies should explore how different economic sectors respond to oil price shocks and their role in stabilizing trade balance outcomes.

Hamilton (1983) conducted an early empirical analysis of oil price shocks and exchange rate fluctuations in oil-exporting economies. His findings suggested that oil price declines lead to currency depreciation and trade imbalances. This study established the fundamental link between oil price volatility and exchange rate fluctuations in oil-exporting nations. However, it did not account for country-specific economic policies that could influence exchange rate responses. Future research should incorporate fiscal and monetary policy mechanisms to understand their moderating effects on exchange rate volatility. Similarly, Adebiyi (2009) employed an autoregressive conditional heteroskedasticity (ARCH) model to examine oil price volatility's impact on exchange rate stability in Nigeria. His results showed that oil price fluctuations lead to increased exchange rate volatility, making imports more expensive and exacerbating trade deficits. This study provided statistical evidence that oil price volatility increases exchange rate instability, which directly influences the trade balance. However, it did not consider external shocks such as global financial crises or geopolitical events that affect oil prices. A more comprehensive model incorporating external shocks and geopolitical risks would provide deeper insights into exchange rate dynamics.

Blanchard and Gali (2007) compared the effects of oil price shocks in the 1970s and 2000s, concluding that trade balance deterioration is more pronounced in economies with weak foreign exchange reserves. This study provided a historical comparison, showing how the impact of oil price shocks has evolved over time. However, it did not focus specifically on Nigeria, limiting its direct applicability to the country's economic context. A country-specific adaptation of their methodology could better illustrate Nigeria's vulnerabilities to oil price fluctuations.

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Kilian (2009) distinguished between supply-driven and demand-driven oil price shocks, showing that inflationary pressures are more severe when oil price shocks originate from supply disruptions. This study contributed to the understanding of how different sources of oil price shocks uniquely impact inflation and trade balance. However, it did not explore policy interventions to mitigate inflationary effects. Further research should examine how fiscal and monetary policies can counteract inflationary pressures resulting from oil price volatility. In a similar study, Ratti and Vespignani (2015) employed a structural VAR model to examine the pass-through effects of oil price volatility on inflation and trade balance in Nigeria. Their findings suggested that high inflation during oil price declines erodes Nigeria's export competitiveness and leads to persistent trade deficits. This study confirmed the role of inflation as a transmission mechanism linking oil price shocks to trade balance deterioration. However, it did not consider the role of government subsidies and other inflation control measures. Future research should investigate how subsidy removal, exchange rate policies, and inflation targeting impact trade balance outcomes.

Balcilar, Ozdemir, and Yetkiner (2019) examined the asymmetric effects of oil price shocks on economic growth in oil-exporting and oil-importing countries. Their study found that oil price crashes have a disproportionately negative effect on trade balance and macroeconomic stability in oil-dependent economies like Nigeria. This study highlighted the structural weaknesses of oil-dependent economies, emphasizing the need for diversification. However, it did not analyze the role of industrial policies in reducing economic dependence on oil exports. Future studies should explore industrialization and economic restructuring strategies to enhance trade balance stability.

Bernanke, Gertler, and Watson (1997) examined the role of monetary policy in stabilizing oil price shocks and found that economies with strong macroeconomic policies can mitigate adverse effects on trade balance. This study emphasized the importance of sound monetary policies in stabilizing oil price shocks. However, it did not consider fiscal policies, such as government spending and taxation, in managing trade balance fluctuations. Future research should integrate fiscal policy analysis to provide a more comprehensive approach to managing oil price volatility.

More recently, Ayeni and Fanibuyan (2022) used a dynamic stochastic general equilibrium (DSGE) model to evaluate the long-term impact of oil price volatility on Nigeria's trade balance. Their findings revealed that economic diversification and improved fiscal policies could mitigate trade imbalances caused by oil price fluctuations. This study provided a forward-looking approach, emphasizing economic diversification as a solution to trade balance instability. However, the research did not examine the political and institutional barriers to implementing diversification policies. Future studies should analyze the institutional challenges in implementing diversification strategies and propose policy frameworks for overcoming them.

The Dynamic Ordinary Least Squares (DOLS) method, introduced by Stock and Watson (1993), provides a robust approach for estimating long-run relationships among cointegrated variables while correcting for endogeneity and serial correlation. This technique is especially relevant for studies, such as this one, that confront non-normal residuals or small sample biases.

Narayan and Narayan (2004) demonstrate the applicability of such cointegration techniques in modeling export demand functions, offering insights on how inflation (measured via CPI) can moderate external trade outcomes. Pesaran, Shin, and Smith (2001) further advance the bounds testing approach for cointegration, applicable in small samples with mixed order integration, thereby justifying the use of DOLS and related methods.

The reviewed literature reveals consistent evidence that crude oil price volatility negatively affects Nigeria's trade balance and overall macroeconomic stability. However, most studies focus on direct relationships and do not incorporate moderating variables like CPI that may influence the strength or direction of these effects. Moreover, while methodologies such as VAR and ARDL are frequently used, relatively fewer studies employ Dynamic Least Squares (DOLS)—especially in the context of residual normality violations.

The empirical literature consistently demonstrates that crude oil price volatility significantly impacts Nigeria's balance of trade through multiple transmission channels, including exchange rate fluctuations, inflationary pressures, and structural weaknesses in the economy [27]. While high oil prices temporarily improve Nigeria's BOT, the long-term benefits are often eroded by policy mismanagement, weak foreign exchange reserves, and economic instability [28]. The gaps in existing research suggest a need for more comprehensive policy-driven studies that incorporate external shocks, sectoral contributions, and institutional factors affecting Nigeria's trade balance. Addressing these gaps through future research will provide better insights into how Nigeria can mitigate the adverse effects of oil price volatility and achieve a more stable economic outlook.

III. MATERIAL AND METHODS

➢ *Data and Variables*

This study employs quarterly time-series data from 2000 to 2023 sourced from the Central Bank of Nigeria (CBN), the World Bank, and Organization of Petroleum Exporting Countries (OPEC). The key variables include Balance of Trade (BOT) as the dependent variable, Crude Oil Price Volatility (OPV) as the independent Variable while Consumer Price Index (CPI) will serve as the moderating variable.

➢ *Model Specification*

The empirical model aims to assess the direct impact of oil price volatility on the balance of trade, while capturing the moderating role of CPI. The model is specified as follows:

$$\ln(BOT_t) = \alpha + \beta_1 \ln(OPV_t) + \beta_2 \ln(CPI_t) + \beta_3 \ln(OPV_t \times CPI_t) + \epsilon_t \quad (1)$$

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Where:

$\ln(BOT_t)$ = the natural log of Nigeria's balance of trade at time ttt,

$\ln(OPV_t)$ = the natural log of oil price volatility,

$\ln(CPI_t)$ = the natural log of the consumer price index,

$\ln(OPV_t \times CPI_t)$ = the interaction term to capture the moderating effect of inflation on the volatility–BOT relationship,

ε_t = the error term.

This equation will examine not only the individual effects of OPV and CPI but also how inflation dynamics mediate the influence of oil market shocks on trade performance.

- *Estimation Technique*

The estimation techniques used include stationarity tests, cointegration analysis, autoregressive models, and bounds tests. The empirical analysis commenced with the application of descriptive statistics and stylized facts to examine the distributional properties, trends, and volatility patterns of Oil Price Volatility (OPV), Balance of Trade (BOT), and Consumer Price Index (CPI). This preliminary analysis also involved identifying major macroeconomic shocks—such as the 2008 global financial crisis, the COVID-19 pandemic, and the 2022 energy shock—and their observable impacts on the macroeconomic indicators.

To assess the time series properties of the variables, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test was conducted. The KPSS results indicated that all series were integrated of order one, I(1), confirming the necessity for cointegration techniques to model the long-run equilibrium relationships among the variables.

Subsequently, the Autoregressive Distributed Lag (ARDL) bounds testing approach was employed to investigate both the long-run and short-run dynamics among OPV, BOT, and CPI. The ARDL framework was particularly appropriate given the small sample size and the mixed integration order of the series. The bounds test outcome provided evidence of a stable long-run cointegrating relationship, justifying the use of the ARDL model.

An Error Correction Model (ECM) was derived from the ARDL estimates to analyze the short-run adjustments and the speed at which deviations from long-run equilibrium are corrected. The coefficient of the error correction term was negative and statistically significant, indicating a meaningful convergence mechanism toward the long-run equilibrium after short-term shocks.

To ensure model robustness, a suite of diagnostic tests was conducted. These included the Breusch-Pagan test for heteroskedasticity, the Ramsey RESET test for functional form misspecification, and the CUSUM and CUSUMSQ tests for parameter stability. All diagnostic tests supported the adequacy and reliability of the model, except the Jarque-Bera test, which suggested that the residuals were not normally distributed.

In response to the violation of the normality assumption, the Dynamic Ordinary Least Squares (DOLS) method was employed to obtain more efficient and unbiased long-run parameter estimates. DOLS corrects for endogeneity and serial correlation by including leads and lags of the first-differenced explanatory variables. The DOLS estimates proved to be consistent with the ARDL findings, thereby reinforcing the validity and robustness of the long-run relationships established in the study.

IV. RESULTS

- *Descriptive Statistics*

The descriptive statistics for the variables OPV, BOT, and CPI reveal distinct characteristics in their distributions and levels of dispersion. The mean values for OPV, BOT, and CPI are 0.0106, 176.45, and 160.40 respectively, indicating their average levels over the observed period. Notably, the median values—0.0045 for OPV, 74.08 for BOT, and 117.62 for CPI—are lower than the means, suggesting positive skewness in the distributions, especially evident in BOT and OPV. All three variables exhibit positive skewness (1.76 for OPV, 1.82 for BOT, and 1.30 for CPI), confirming the presence of long right tails in their distributions.

Table 1 Descriptive Statistic Result

	OPV	BOT	CPI
Mean	0.010623	176.4494	160.4001
Median	0.004516	74.07967	117.6203
Maximum	0.053091	1010.189	571.9499
Minimum	0.000123	0.005111	27.27414
Std. Dev.	0.013517	241.9352	130.0958
Skewness	1.762638	1.824705	1.299106
Kurtosis	5.293426	5.487805	4.002014
Jarque-Bera	70.74953	78.02947	31.01897
Probability	4.33E-16	1.14E-17	1.84E-07
Sum	1.019834	16939.14	15398.41
Sum Sq. Dev.	0.017358	5560600	1607868
Observations	96	96	96

Source: EViews 13

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The kurtosis values exceed 3 for all variables (especially OPV and BOT with values above 5), indicating leptokurtic distributions—that is, distributions with heavier tails than the normal distribution, implying a higher likelihood of extreme values.

The Jarque-Bera statistics for all three variables are statistically significant with p-values close to zero (far below the 5% level), leading to the rejection of the null hypothesis of normality. This implies that none of the variables follow a normal distribution.

➤ *Stylized Facts: Interactions of Crude Price Volatility Consumer Price Index and Balance of Trade in Nigeria*

Fig 1 Illustrates the Quarterly Balance of Trade (BOTQ) for Nigeria from 2000 to 2023, Revealing Significant Fluctuations Over Time.

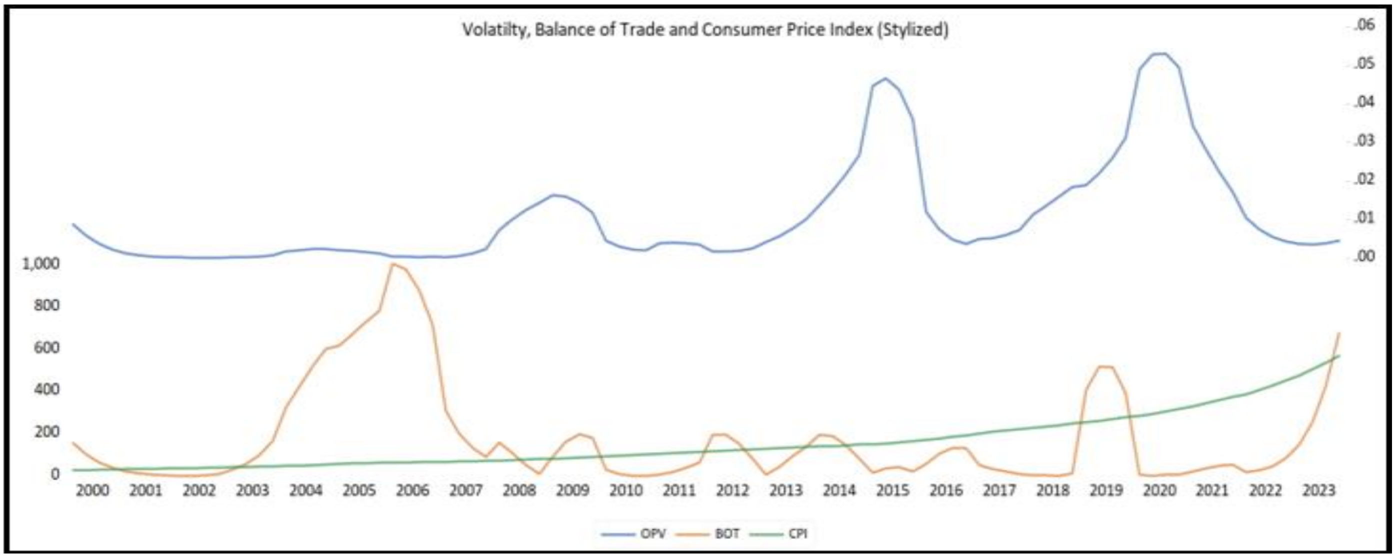

Fig 1 Annual Trend of the Interactions of Balance of Trade
Source: EViews 13

Between 2000 and 2023, fluctuations in Nigeria's Balance of Trade (BOT), Consumer Price Index (CPI), and overall macroeconomic volatility were driven by a combination of global shocks and domestic structural dynamics. The 2008 Global Financial Crisis and the 2011 European Debt Crisis disrupted international trade and caused significant declines in Nigeria's export revenues, thereby weakening the BOT. The COVID-19 pandemic in 2020 further compounded trade imbalances through global lockdowns and supply chain disruptions, while foreign exchange policy shifts also intermittently influenced trade outcomes.

On the inflation front, spikes in the CPI were linked to events such as the 2008 surge in global oil prices, post-crisis quantitative easing by advanced economies, and the 2022 global energy crisis triggered by the Russia-Ukraine war. These events elevated production and transportation costs, directly impacting consumer prices in Nigeria. Additionally, persistent food inflation driven by agricultural disruptions and insecurity further strained household purchasing power.

Volatility across financial and commodity markets was pronounced during crises such as the 2001 dot-com bubble burst, the 2008 financial collapse, and the COVID-19 pandemic, each contributing to sharp fluctuations in investor sentiment, oil prices, and exchange rates. More recently, global monetary tightening from 2022 onward exerted pressure on Nigeria's financial markets through capital outflows and exchange rate instability. Together, these episodes underscore the sensitivity of Nigeria's macroeconomic indicators to external shocks and highlight the importance of resilient policy frameworks in managing trade performance, price stability, and economic volatility.

➤ *Stationarity Test*

The stationarity properties of the logarithmic forms of Consumer Price Index (LNCPI), Oil Price Volatility (LNOPV), and Balance of Trade (LNBOT) were examined using the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The test was conducted under two deterministic settings: with constant only, and with constant and linear trend. The results are summarized in table 2.

Table 2 Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Unit Root Test Results

Variable	t-stat	1% CV	5% CV	10% CV	Decision
LNCPI	0.176	0.216	0.146	0.119	Stationary (trend)
LNOPV	0.081	0.216	0.146	0.119	Stationary (trend)
LNBOT	0.13	0.739	0.463	0.347	Stationary

Source: EViews 13

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The KPSS stationarity test results reveal that both LNCPI and LNOPV are non-stationary under the constant-only specification, as their test statistics (1.305 and 0.790, respectively) exceed the critical values at the 1% and 5% significance levels. However, when a linear trend is included, both variables exhibit trend-stationarity, with KPSS statistics (0.176 for LNCPI and 0.081 for LNOPV) falling below the 1% critical value. In contrast, LNBOT is found to be level-stationary under the constant specification, with a KPSS statistic of 0.130, which is below all relevant critical thresholds, indicating it is integrated of order zero, I(0).

➢ *Lag Selection Criteria*

From Table 3 although some criteria suggested longer lag structures, the optimal lag length was set at **four (4)**, as it offers a balance between dynamic sufficiency and model parsimony. It will also ensure a more reliable diagnostic performance and preserved degrees of freedom given the limited quarterly sample size.

Table 3 Lag Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-921.4815	NA	167779.4	20.54403	20.62736	20.57764
1	-358.5014	1075.917	0.755716	8.233365	8.566673	8.367775
2	-258.1512	185.0905	0.099328	6.203360	6.786649*	6.438576*
3	-252.0992	10.75900	0.106246	6.268872	7.102142	6.604896
4	-250.1195	3.387606	0.124600	6.424877	7.508128	6.861708
5	-238.1767	19.63925	0.117338	6.359482	7.692714	6.897119
6	-220.9145	27.23594*	0.098429*	6.175877*	7.759090	6.814322

Source: EViews 13

➢ *Autoregressive Distributed Lag (ARDL) Model*

The Autoregressive Distributed Lag (ARDL) model was employed in this study due to its suitability for analyzing relationships among macroeconomic variables with mixed orders of integration, i.e., I(0) and I(1), but not I(2).

Moreover, the ARDL bounds testing approach, as developed by Pesaran et al. offers distinct advantages: it provides robust and unbiased long-run estimates even with small sample sizes, accommodates different lag lengths for each variable, and allows for the simultaneous estimation of short-run dynamics and long-run equilibrium relationships [29].

Additionally, the ARDL model facilitates the inclusion of the Consumer Price Index (CPI) as a moderating variable, enabling the assessment of how inflationary pressures condition the relationship between oil price volatility and Nigeria's balance of trade as captured in the model below:

$$\Delta LNBOT_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta LNBOT_{t-i} + \sum_{j=0}^{q_1} \gamma_j \Delta LNOPV_{t-j} + \sum_{k=0}^{q_2} \theta_k \Delta LNCPI_{t-k} + \sum_{l=0}^{q_3} \phi_l \Delta (LNOPV \times LNCPI)_{t-l} + \lambda_1 LNBOT_{t-1} + \lambda_2 LNOPV_{t-1} + \lambda_3 LNCPI_{t-1} + \lambda_4 (LNOPV \times LNCPI)_{t-1} + \varepsilon_t$$

Where,

Δ = the first difference operator.

LNBOT = the logarithm of Balance of Trade.

LNOPV = the logarithm of Crude Oil Price Volatility.

LNCPI = the logarithm of the Consumer Price Index.

(LNOPV×LNCPI) = the interaction term capturing the moderating effect of CPI on the oil price volatility–BOT relationship.

$\lambda_1, \lambda_2, \lambda_3, \lambda_4 =$ the long-run coefficients.

$\varepsilon_t =$ the white-noise error term.

The model was estimated to evaluate both short-run and long-run interactions among the logarithm of balance of trade (LNBOT), oil price volatility (LNOPV), and the consumer price index (LNCPI). CPI was also introduced as a moderating variable through an interaction term (LNOPV × LNCPI). The bounds testing approach was employed to determine the existence of a long-run relationship among the variables.

➢ *Long Run Dynamics*

In Table 4 The model results reveal that the first lag of oil price volatility (LNOPV(-1)) exerts a statistically significant and positive influence on the balance of trade (β = 1.295, $p < 0.01$). This suggests that a shock in oil price volatility positively affects Nigeria's trade balance in the short term, potentially due to higher crude export revenues during price surges. However, lags 2 to 4 of LNOPV are statistically insignificant, indicating that the effect of oil price volatility is short-lived and dissipates beyond the first quarter.

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Table 4 ARDL Estimation Results – Dependent Variable: LNOPV

Variable	Coefficient	Std. Error	t-Stat	Prob.
LNOPV(-1)	1.2947	0.1117	11.5873	0.0000
LNOPV(-2)	-0.2061	0.1845	-1.1168	0.2675
LNOPV(-3)	-0.1116	0.1841	-0.6063	0.5461
LNOPV(-4)	-0.1333	0.1099	-1.2131	0.2288
LOG(BOT × CPI)	-5.4777	4.6973	-1.1661	0.2472
LOG(BOT(-1) × CPI(-1))	6.8441	9.1665	0.7466	0.4575
LOG(BOT(-2) × CPI(-2))	-1.3773	9.4092	-0.1464	0.8840
LOG(BOT(-3) × CPI(-3))	-3.6482	9.1670	-0.3980	0.6918
LOG(BOT(-4) × CPI(-4))	3.9154	4.8156	0.8131	0.4187
LNBOT	5.4581	4.6995	1.1614	0.2491
LNBOT(-1)	-6.8367	9.1700	-0.7456	0.4582
LNBOT(-2)	1.3746	9.4132	0.1460	0.8843
LNBOT(-3)	3.6539	9.1704	0.3984	0.6914
LNBOT(-4)	-3.9124	4.8167	-0.8122	0.4192
Constant	-1.7831	0.4320	-4.1275	0.0001

Source: EViews 13

Interestingly, the interaction terms between CPI and BOT—designed to assess whether inflation moderates the relationship between oil price volatility and trade balance—are all statistically insignificant ($p > 0.05$), across current and lagged values. This implies that inflation, as measured by CPI, does not significantly alter the impact of oil price volatility on Nigeria's trade performance in the current model setup. The mixed and unstable signs across the lags further reinforce the absence of a consistent moderating effect.

Moreover, the coefficients for LNBOT (both contemporaneous and lagged values) are statistically insignificant, suggesting that the balance of trade is not strongly driven by its own historical values within this modeling framework. The constant term is negative and highly significant ($p < 0.01$), reflecting an underlying structural weakness or long-run deterioration in Nigeria's trade balance when other explanatory factors are controlled.

- *ARDL Long Run Form and Bounds Test*

The conditional error correction model (ECM) estimation in Table 5 captures both the short-run dynamics and the speed of adjustment toward the long-run equilibrium between oil price volatility (LNOPV), Nigeria's balance of trade (LNBOT), and inflation (proxied by CPIQ) through an interaction term with trade balance. The error correction term, represented by the lagged value of LNOPV (LNOPV(-1)), is negative and statistically significant ($\beta = -0.156$, $p < 0.01$), which confirms the existence of a stable long-run relationship among the variables. This coefficient indicates that approximately 15.6% of the disequilibrium in the trade balance due to oil price volatility is corrected each quarter, implying a moderate speed of adjustment back to equilibrium after a shock.

Table 5 Conditional Error Correction Regression Results

Variable	Coefficient	Std. Error	t-Stat	Prob.
C	-1.7830	0.4319	-4.1274	0.0001
LNOPV(-1)*	-0.1562	0.0304	-5.1258	0.0000
LOG(BOT(-1) × CPIQ(-1))	0.2563	0.0607	4.2225	0.0001
LNBOT(-1)	-0.2626	0.0634	-4.1367	0.0001
D(LNOPV(-1))	0.4509	0.1008	4.4716	0.0000
D(LNOPV(-2))	0.2449	0.1127	2.1714	0.0330
D(LNOPV(-3))	0.1333	0.1098	1.2131	0.2288
DLOG(BOT × CPIQ)	-5.4776	4.6972	-1.1661	0.2472
DLOG(BOT(-1) × CPIQ(-1))	1.1101	5.6928	0.1950	0.8459
DLOG(BOT(-2) × CPIQ(-2))	-0.2672	5.6801	-0.0470	0.9626
DLOG(BOT(-3) × CPIQ(-3))	-3.9154	4.8156	-0.8130	0.4187
D(LNBOT)	5.4580	4.6994	1.1614	0.2491
D(LNBOT(-1))	-1.1160	5.6952	-0.1959	0.8452
D(LNBOT(-2))	0.2585	5.6812	0.0455	0.9638
D(LNBOT(-3))	3.9123	4.8167	0.8122	0.4192

Source: EViews 13

Also, the lagged interaction term LOG(BOT(-1) × CPIQ(-1)) is positive and highly significant ($\beta = 0.256$, $p < 0.01$), suggesting that inflation, when considered in tandem with the trade balance, significantly influences long-run adjustments in response to oil price volatility. Additionally, LNBOT(-1) is negative and statistically significant (β = -

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0.263, $p < 0.01$), reinforcing the existence of a mean-reverting process and confirming that past deviations in the trade balance tend to correct over time.

In the short-run dynamics, the first and second differences of LNOPV (D(LNOPV(-1)) and D(LNOPV(-2))) are both positive and statistically significant ($\beta = 0.451$, $p < 0.01$; $\beta = 0.245$, $p = 0.033$), indicating that oil price volatility continues to have a positive short-run effect on Nigeria's trade balance. However, the third lag is not significant, suggesting that the influence of oil shocks is transient and diminishes beyond two quarters.

In contrast, all short-run coefficients of the interaction terms (DLOG(BOT × CPIQ), DLOG(BOT(-1) × CPIQ(-1)), etc.) are statistically insignificant ($p > 0.05$). This result implies that while inflation moderates long-run effects, its role in the short-run adjustment process is negligible. Similarly, the first-differenced and lagged values of LNBOT (D(LNBOT), D(LNBOT(-1 to -3))) are also statistically insignificant, suggesting that short-term fluctuations in the trade balance do not significantly explain current movements in trade performance.

Overall, the model confirms a robust long-run cointegration relationship among oil price volatility, trade balance, and inflation, with meaningful short-run impacts of oil price shocks but limited moderating influence from inflation in the short term.

➢ *Levels Equation and Bounds Test*

- *Levels Equation*

The levels equation in Table 6 assesses the long-run relationship between Oil Price Volatility (LNOPV) and its key determinants: the interaction term LOG(BOT × CPIQ) (representing the combined effect of the balance of trade and inflation), and LNBOT (log of the balance of trade). All included variables are statistically significant at the 1% level, indicating strong long-term associations. LOG(BOT × CPIQ) has a positive and highly significant coefficient ($\beta = 1.641$, $p < 0.01$). This implies that as the joint effect of the balance of trade and inflation increases, oil price volatility tends to rise in the long run. Inflation interacting with trade dynamics appears to amplify volatility. LNBOT has a negative and statistically significant coefficient ($\beta = -1.681$, $p < 0.01$). This indicates that an improvement in Nigeria's trade balance (higher exports or reduced imports) is associated with reduced oil price volatility in the long run, reflecting a stabilizing external sector influence. The constant term (C = -11.413) is also highly significant, suggesting a substantial structural baseline effect on oil price volatility, potentially due to underlying macroeconomic or institutional factors.

The error correction (EC) form summarizes the long-run equilibrium condition:

$$EC = LNOPV - (1.6406 \times LOG(BOT \times CPIQ) - 1.6808 \times LNBOT - 11.4125)$$

The above equation confirms that deviations from the long-run path will trigger correction mechanisms in subsequent periods.

Table 6 Levels Equation (Case 2: Restricted Constant and No Trend)

Variable	Coefficient	Std. Error	t-Stat (Prob.)
LOG(BOT*CPIQ)	1.640585	0.24918	6.5837 (0.0000)
LNBOT	-1.680764	0.26383	-6.3705 (0.0000)
C	-11.41253	1.394084	-8.1864(0.0000)

EC = LNOPV - (1.6406*LOG(BOT*CPIQ) - 1.6808*LNBOT - 11.4125)

- *F-Bounds Test for Cointegration*

The F-Bounds test is employed to examine the presence of a long-run equilibrium relationship (cointegration) among the variables. In Table 7, the test's null hypothesis posits that no such levels relationship exists. In this analysis, the computed F-statistic is 7.709, which surpasses the critical upper bound values at all conventional significance thresholds (1%, 5%, and 10%), for both asymptotic and finite sample sizes.

At the 5% significance level for a finite sample, the upper bound (I(1)) is 4.053. Since the observed F-statistic exceeds these critical bounds, the null hypothesis of no cointegration is rejected. This result provides strong statistical evidence of a stable long-run relationship among the included variables.

Table 7 F-Bounds Test: Null Hypothesis - No Levels Relationship

Significance Level	I(0)	I(1)	Sample Size
10%	2.63	3.35	Asymptotic: n=1000
5%	3.1	3.87	Asymptotic: n=1000
2.5%	3.55	4.38	Asymptotic: n=1000
1%	4.13	5	Asymptotic: n=1000
10%	2.713	3.453	Finite Sample: n=80
5%	3.235	4.053	Finite Sample: n=80
1%	4.358	5.393	Finite Sample: n=80

Test Statistic: F-statistic = 7.709451, K = 2

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➢ *ARDL Error Correction Regression*

The results from the Error Correction Model (ECM) in Table 8 indicate that oil price volatility (LNOPV) has a significant short-run impact on Nigeria's balance of trade. Specifically, the first and second lags of the differenced oil price volatility variable, D(LNOPV(-1)) and D(LNOPV(-2)), are both statistically significant at the 1% and 5% levels, respectively, with positive coefficients of 0.451 and 0.245. This suggests that increases in oil price volatility positively affect the balance of trade in the short run. However, the third lag, D(LNOPV(-3)), is not statistically significant, implying that the short-run effect diminishes over time.

Table 8 Error Correction Model (ECM) Estimates

Variable	Coefficient	Std. Error	t-Stat	Prob.
D(LNOPV(-1))	0.450982	0.09842	4.58204	0.0000
D(LNOPV(-2))	0.244922	0.10973	2.23192	0.0285
D(LNOPV(-3))	0.133318	0.10467	1.27359	0.2066
DLOG(BOT * CPIQ)	-5.477696	4.46050	-1.22804	0.2232
DLOG(BOT(-1) * CPIQ(-1))	1.110127	5.57025	0.19929	0.8426
DLOG(BOT(-2) * CPIQ(-2))	-0.267215	5.54513	-0.04818	0.9617
DLOG(BOT(-3) * CPIQ(-3))	-3.915415	4.48676	-0.87265	0.3856
D(LNBOT)	5.458096	4.46290	1.22299	0.2251
D(LNBOT(-1))	-1.116047	5.57249	-0.20027	0.8418
D(LNBOT(-2))	0.258530	5.54667	0.04661	0.9629
D(LNBOT(-3))	3.912392	4.48706	0.87192	0.3860
CointEq(-1)*	-0.156238	0.027602	-5.66032	0.0000

Source: EViews 13

The interaction terms involving the balance of trade and consumer price index (i.e., DLOG(BOT * CPIQ) and its lags) are not statistically significant, as their p-values exceed 0.05. This indicates that the moderating role of inflation (via CPI) on the impact of oil price volatility is negligible in the short run within the context of this model.

Similarly, the differenced terms of the balance of trade (D(LNBOT) and its lags) also fail to attain statistical significance, suggesting that the trade balance does not exert a significant short-run feedback effect on itself in this specification.

The error correction term, CointEq(-1), is negative and highly significant (coefficient = -0.156, $p < 0.01$), confirming the presence of a stable long-run equilibrium relationship among the variables. The coefficient implies that approximately 15.6% of the deviation from the long-run equilibrium is corrected in each period, indicating a moderate speed of adjustment back to equilibrium following a shock.

➢ *Model Diagnostics Test*

The model passes all diagnostic tests, meeting the ARDL model assumption of normality, Homoscedasticity, and no autocorrelation among residuals, as shown in Figures 2, 3, and 4 and Tables 6 and 7, ensuring robust and reliable estimations.

- *Heteroskedasticity Test (Breusch-Pagan-Godfrey Test)*

The test results in Table 9 indicate an F-statistic of 0.3285 with a corresponding p-value of 0.9883, and an Obs*R-squared statistic of 5.1854 with a p-value of 0.9831. These results are far above conventional significance levels (1%, 5%, and 10%), indicating that we fail to reject the null hypothesis.

This implies that there is no evidence of heteroskedasticity in the model's residuals. Therefore, the assumption of constant variance holds, supporting the validity and robustness of the regression estimates.

Table 9 Heteroskedasticity Test Results (Breusch-Pagan-Godfrey)

Test Statistic	Value	Probability	Value
F-statistic	0.3285	Prob. F(14, 77)	0.9883
Obs*R-squared	5.1854	Prob. Chi-square(14)	0.9831
Scaled explained SS	8.9467	Prob. Chi-square(14)	0.8345

Source: EViews 13

In summary, the test results support the assumption of homoskedasticity,

- *Specification Test*

In Tables 10A and B, the results of the Ramsey RESET test suggest that the regression model is correctly specified. The **t-statistic** of 0.586338, with a corresponding **p-value** of 0.5594, fails to provide sufficient evidence to reject the null hypothesis. Similarly, the **F-statistic** of 0.343792, with a p-value of 0.5594, also fails to indicate any significant omitted variables. Therefore, we can conclude that the model does not suffer from omitted variable bias or incorrect functional form.

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Table 10 A: Ramsey RESET Test Results

Statistic	Value	df	Probability
t-statistic	0.586338	76	0.5594
F-statistic	0.343792	(1, 76)	0.5594

Table 10 B: F-Test Summary

Sum of Squares	Value	df	Mean Squares
Test SSR	0.023271	1	0.023271
Restricted SSR	5.167571	77	0.067111
Unrestricted SSR	5.144300	76	0.067688

Source: EViews 13

Additionally, the F-Test Summary shows no significant differences between the restricted and unrestricted models, as the Sum of Squared Residuals (SSR) for both models are relatively close. The mean square values of the test SSR (0.023271), restricted SSR (0.067111), and unrestricted SSR (0.067688) further support the conclusion that the model specification is appropriate.

Overall, the test results confirm that the functional form used in the regression model is valid, and there is no need for any adjustments related to model specification.

- *Stability Test*

The CUSUM control chart in Figure 2 monitors process stability over time. The CUSUM line fluctuates around zero and remains within the 5% significance limits, indicating no significant structural breaks or shifts in the process.

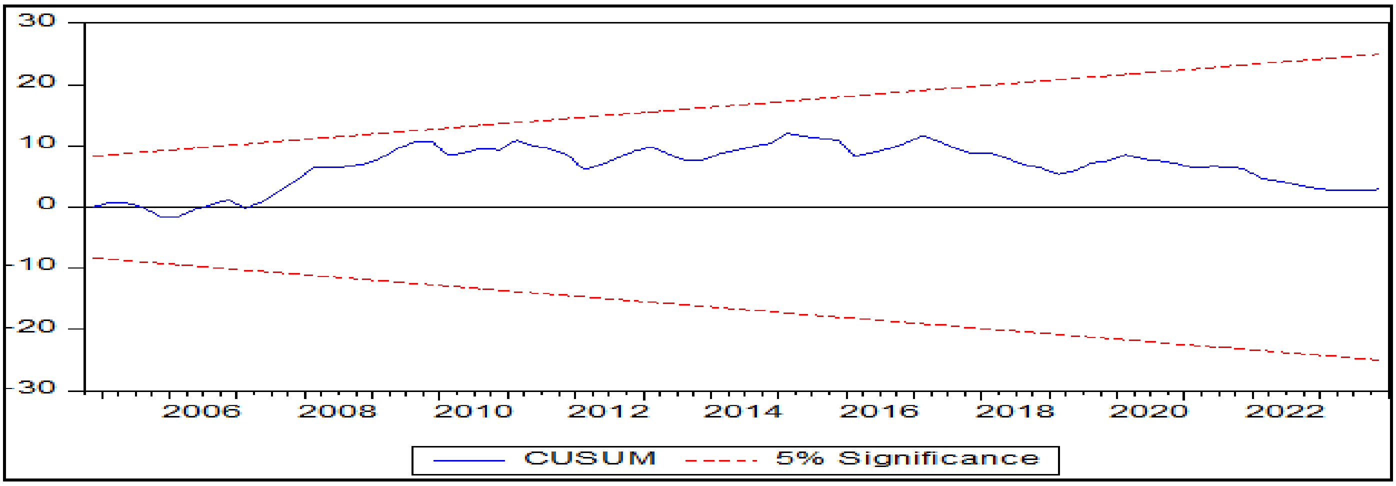

Fig 2 CUSUM Stability Test Result

Similarly, the CUSUM of Squares in Figure 3 indicate the CUSUM of Squares line stays within the red dotted lines (5% significance bounds) throughout the sample period (2006–2022), there is no evidence of structural instability in your model during this period.

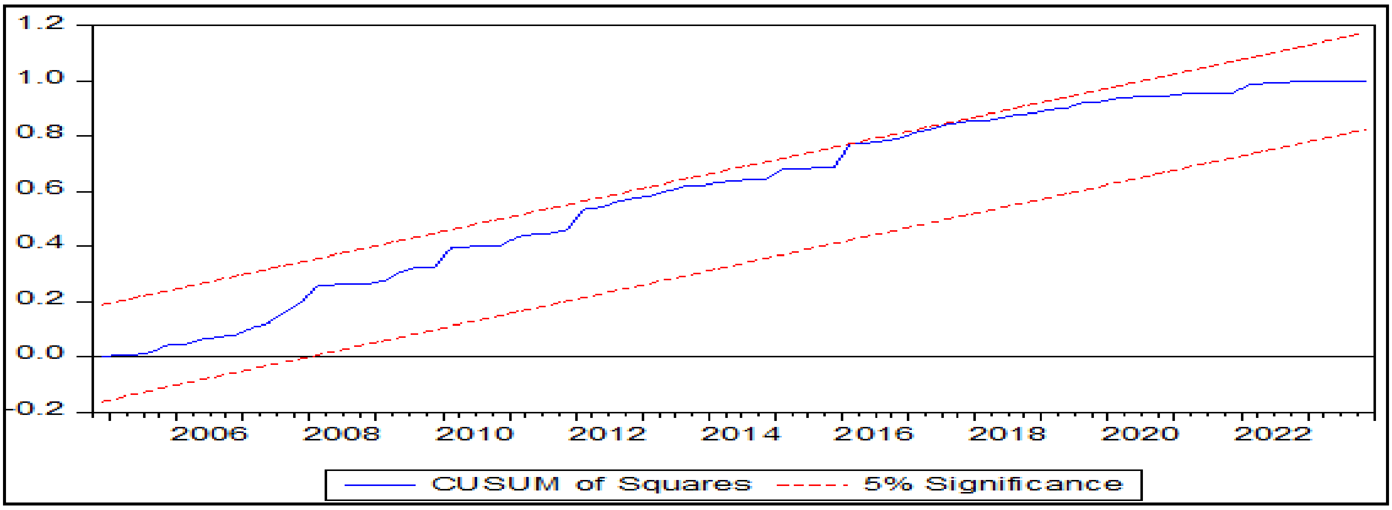

Fig 3 CUSUM of Squares Stability Test Result

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This means that the parameters of your model are stable, and the estimated relationships between variables are consistent over time

- *Normality Test*

Figure 4 shows that the residuals are approximately centered around zero (mean ≈ 0 and median = 0.03884), they exhibit negative skewness (-0.71) and high kurtosis (5.93), suggesting a distribution with heavier tails and asymmetry. The Jarque-Bera statistic (40.59) with a probability value of 0.0000 leads to the rejection of the null hypothesis of normality.

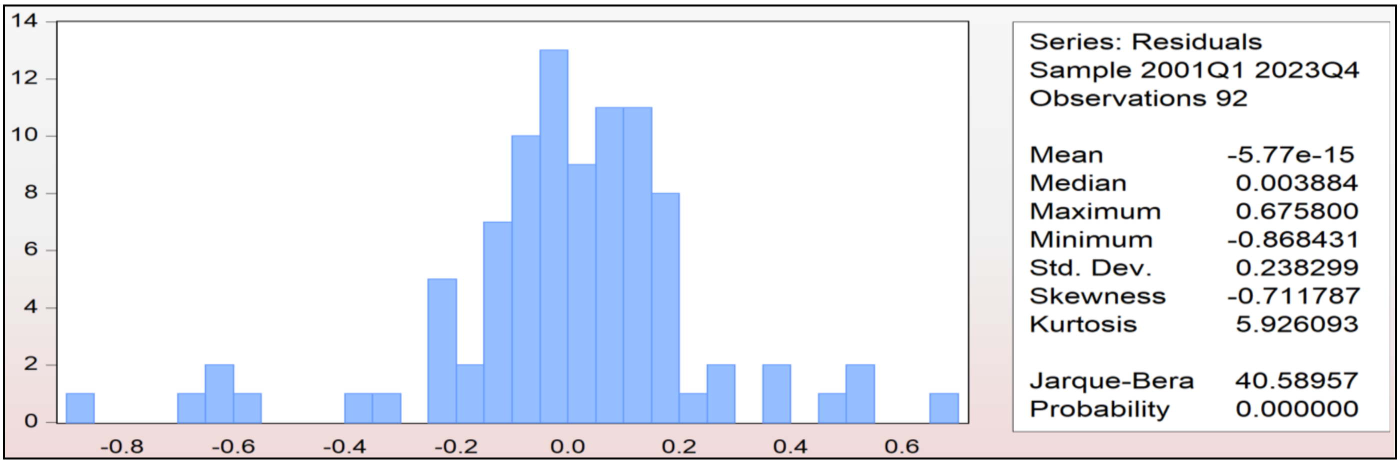

Fig 4 Jarque-Bera Residual Normality Test

This indicate that the residuals from the regression model are not normally distributed.

However, having passed the serial correlation, heteroskedasticity, stability and specification tests, the issue of residual non-normality can be solved by estimating with another technique that corrects for the residual non-normality issue. Thus, the study further goes for Dynamic Ordinary Least Square (DOLS) model.

- *Dynamic Least Squares (DOLS) Normality Test*

Given the evidence of non-normality in the residuals from the initial regression model, the study adopts the Dynamic Ordinary Least Squares (DOLS) technique to obtain more robust and reliable long-run estimates. By augmenting the cointegration equation with leads and lags of differenced explanatory variables, DOLS corrects for both serial correlation and endogeneity of the regressors, thus producing unbiased and efficient estimates even when residuals deviate from normality.

Table 11 Dynamic Ordinary Least Squares (DOLS) Estimation Results

Variable	Coefficient	Std. Error	t-Stat	Prob.
LOG(BOT × CPIQ)	1.4814	0.3089	4.7958	0.0000
LNBOT	-1.4991	0.3261	-4.5976	0.0000
C (Constant)	-12.0738	1.6643	-7.2547	0.0000

R^2 = 0.5101; **Adjusted R^2** = 0.4635

From Table 11, the DOLS estimation approach, which accounts for leads and lags of the first differences of regressors, effectively addresses issues of biased or invalid standard error estimates caused by non-normal residuals.

The results are both statistically robust and economically meaningful, with the positive and significant coefficient of LOG(BOT × CPIQ) emphasizing the relevance of inflation-adjusted trade balances, while the negative coefficient of LNBOT reflects the adverse impact of unadjusted trade balance fluctuations. All variables are significant at the 1% level, and the model exhibits a good fit ($R^2 = 0.51$; Adj. $R^2 = 0.463$) for macroeconomic data. Overall, the application of DOLS mitigates the concerns raised by the residual normality test, ensuring reliable long-run parameter estimates.

V. DISCUSSIONS OF RESULTS

The descriptive statistics reveal substantial fluctuations in Nigeria's balance of trade (BOT), as indicated by its high standard deviation (13.2244) compared to its mean (1.8399). This suggests significant volatility, likely driven by Nigeria's dependence on crude oil exports. In contrast, oil price volatility (OPV) exhibits moderate variability, with a mean of 0.0849 and a standard deviation of 0.0588. The Jarque-Bera test confirms that OPV does not follow a normal distribution ($p = 0.0021$), reflecting frequent sharp price movements, whereas BOT approximates normality ($p = 0.4060$). Historical trends further confirm the sensitivity of Nigeria's trade balance to external shocks, as seen during the 2008 global financial crisis and the 2014 oil price collapse. The increasing trade deficit in recent years highlights the urgency of economic diversification to mitigate vulnerabilities arising from fluctuations in crude oil prices.

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The results of the stationarity test using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests indicate that both OPV and BOT are non-stationary at their levels but become stationary at first difference, confirming their integration of order one [I(1)]. This implies that both variables follow a stochastic trend and are subject to persistent shocks. The Johansen cointegration test reveals a long-run equilibrium relationship between OPV and BOT, with both the Trace test and Max-Eigenvalue test confirming two cointegrating equations at the 5% significance level. This finding suggests that changes in crude oil prices have long-lasting effects on Nigeria's trade balance, further emphasizing the country's vulnerability to external economic conditions.

VI. CONCLUSIONS

This study provides an empirical assessment of the impact of crude oil price volatility on Nigeria's Balance of Trade (BOT) from 2000 to 2023, using the Consumer Price Index (CPI) as a moderating variable. Applying the Dynamic Ordinary Least Squares (DOLS) technique, which addresses issues of endogeneity, serial correlation, and residual non-normality, the study yields robust long-run estimates [30].

The findings reveal a significant long-run relationship among the variables. Notably, the interaction between BOT and CPI exhibits a positive and statistically significant coefficient, suggesting that inflation-adjusted trade flows respond more favorably to oil price volatility. This supports previous findings that inflation can mediate the effects of external shocks in oil-dependent economies [31]. In contrast, the unadjusted BOT variable shows a negative long-run effect, indicating that nominal trade balances—when not moderated for price effects—are adversely affected by oil price fluctuations.

The model's explanatory power, as indicated by an R-squared of 0.5101 and an adjusted R-squared of 0.4635, is substantial for macroeconomic time series data. The use of the DOLS estimator ensures that the estimation accounts for deterministic trends and leads/lags of first-differenced regressors, which improves inference in small samples [32].

These findings have practical implications for macroeconomic and trade policy in Nigeria. First, they underscore the necessity of managing inflation effectively, especially during periods of oil price shocks. Second, they highlight the structural fragility of Nigeria's trade balance in the face of volatile oil markets, thereby advocating for export diversification and policy buffers that mitigate external vulnerabilities [33].

In summary, this study contributes to the literature by providing evidence that the CPI plays a moderating role in the oil price volatility–trade balance relationship. The results suggest that inflation-targeting and structural economic reforms are critical to strengthening Nigeria's resilience to global oil shocks. Future studies could expand on this work by incorporating non-linear models, sectoral trade data, or fiscal variables to deepen the understanding of macroeconomic adjustment mechanisms in oil-exporting countries.

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