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Exchange Rate Volatility and Trade Balance Dynamics in Nigeria: Evidence from a Nonlinear ARDL Approach

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ABSTRACT

This study examines the impact of exchange rate volatility on Nigeria's trade balance using quarterly data from Q1 1990 to Q4 2025. The study employs Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) models to capture both symmetric and asymmetric effects of exchange rate movements. Unit root tests reveal mixed orders of integration among the variables, while the Johansen cointegration test confirms the existence of a long-run relationship among trade balance, exchange rate, inflation, economic growth, and trade openness. The ARDL error correction model indicates that approximately 25% of short-run disequilibrium is corrected each period. Long-run results show that trade openness significantly improves trade balance, whereas exchange rate, inflation, and economic growth have insignificant effects. The NARDL results reveal asymmetric exchange rate effects: appreciation significantly worsens trade balance while depreciation has insignificant effects. Diagnostic tests confirm model stability and absence of serial correlation. The study concludes that exchange rate depreciation alone may not improve Nigeria's trade balance due to structural import dependence. The study recommends exchange rate stability, export diversification, and industrial development to strengthen Nigeria's external sector performance.

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Keywords: Exchange rate volatility, Trade balance, Autoregressive distributed lag, Nigeria

INTRODUCTION

The real exchange rate and its influence on macroeconomic performance continue to attract significant attention from policymakers, academics, and development practitioners, particularly in developing and import-dependent economies such as Nigeria. Exchange rate movements affect price competitiveness, capital flows, inflation, and overall external sector stability. Consequently, policymakers adopt various exchange rate regimes and intervention strategies to minimize external imbalances and reduce excessive volatility.

Nigeria's economy has experienced persistent fluctuations in the value of the naira against major international currencies. These fluctuations have created substantial uncertainty for businesses, investors, policymakers, and households. Recent empirical evidence (Adekunle, 2025) reveals that exchange rate movements significantly influence Nigeria's trade balance, affecting both export performance and import dynamics. While exchange rate stability can enhance foreign reserves, strengthen investor confidence, and promote economic growth, persistent volatility may worsen trade imbalances, deplete foreign exchange reserves, and amplify macroeconomic instability.

From a theoretical standpoint, this study draws primarily on the Uncertainty (Risk-Aversion) Theory and the Absorption Theory of Trade Balance. The uncertainty theory, rooted in international trade under risk (Clark, 1973; De Grauwe, 1988), assumes that economic agents are risk-averse. Increased exchange rate volatility raises uncertainty, discourages trade activities, and reduces export expansion. The absorption theory (Alexander, 1952) posits that trade balance equals the difference between national output (Y) and domestic absorption (A). Accordingly, a real depreciation is expected to improve the trade balance in the long run if output grows relative to domestic spending.

However, for an import-dependent economy such as Nigeria where production relies heavily on imported intermediate goods and non-oil exports remain weak, the relationship between exchange rate volatility and trade balance is likely to be complex and potentially asymmetric. Emerging literature suggests that increases in exchange rate volatility may affect trade differently from decreases in volatility (Bahmani-Oskooee & Aftab, 2017; Chien *et al*., 2020; Xu *et al*., 2022). High volatility may deter exports due to uncertainty, whereas reduced volatility may encourage trade expansion.

Although several studies have examined exchange rate-trade balance dynamics in Nigeria, many rely on linear estimation techniques that assume symmetric responses to exchange rate movements, implying that appreciation and depreciation exert equal but opposite effects. However, this assumption is overly restrictive, particularly for developing economies like Nigeria characterized by structural rigidities, import dependence, and weak production capacity. Empirical evidence suggests that exchange rate appreciation may exert stronger adverse effects on trade balance than the beneficial effects of depreciation (Shin *et al*., 2014; Bahmani-Oskooee & Aftab, 2017). Furthermore, limited attention has been given to integrating both exchange rate depreciation and volatility within a unified nonlinear framework, thereby creating a significant research gap. To address these limitations, the nonlinear ARDL (NARDL) approach is employed, as it decomposes exchange rate movements into positive and negative changes, enabling the analysis of asymmetric short-run and long-run dynamics that linear models fail to capture.

This study contributes to the literature in three major ways. First, it extends existing studies by jointly examining exchange rate volatility and trade balance within a unified nonlinear framework. Second, it provides country-specific evidence for Nigeria using updated quarterly data spanning 1990 to 2025, thereby improving the relevance of policy implications. Third, by applying the NARDL model, the study uncovers asymmetric effects of exchange rate movements, offering deeper insights into how appreciation and depreciation differently influence trade balance. These contributions enhance both empirical and methodological understanding of exchange rate–trade dynamics in developing economies.

This study therefore investigates both the symmetric and asymmetric effects of exchange rate volatility on Nigeria's trade balance using

Quarterly data from 1995 to 2025 using ARDL and NARDL approaches. By distinguishing short-run and long-run dynamics and explicitly accounting for asymmetry, the study provides deeper insights into exchange rate management and external sector stability.

The remainder of the paper is structured as follows: Section 2 reviews the theoretical and empirical literature; Section 3 outlines the methodology and data; Section 4 presents and discusses the empirical results; while Section 5 concludes the study with policy recommendations.

LITERATURE REVIEW

The exchange rate is the price of one currency in terms of another. Exchange rate regimes may be fixed, floating, or managed float depending on the degree of government intervention (Krugman, Obstfeld & Melitz, 2018). Nigeria transitioned from a fixed exchange rate system before the Structural Adjustment Programme (SAP) to a managed floating regime after 1986. Since then, the Naira has experienced sustained depreciation and heightened volatility, reflecting macroeconomic imbalances and structural vulnerabilities.

Exchange rate depreciation refers to a sustained decline in the domestic currency's value under a floating or managed regime (Bahmani-Oskooee & Ratha, 2004). Exchange rate volatility refers to unpredictable fluctuations in exchange rate movements over time and is commonly measured using ARCH/GARCH models (Bollerslev, 1986). Trade balance is defined as the difference between exports and imports of goods and services and constitutes a key component of the current account (Obstfeld & Rogoff, 1996). It reflects a Nation's competitiveness and external sustainability.

Several theories explain the exchange rate–trade balance nexus. This study is anchored primarily on Uncertainty (Risk-Aversion), J-Curve and Absorption Theories. Uncertainty (Risk-Aversion) Theory shows that heightened exchange rate volatility increases transaction risk, discourages trade, and adversely affects the trade balance, especially in economies with weak hedging mechanisms (De Grauwe,1988), while J-Curve Theory reveals that depreciation may initially worsen trade balance due to contractual rigidities and inelastic demand, but improve it in the long run once quantities adjust (Bahmani-Oskoee & Ratha, 2004). Absorption Theory posits that trade balance improves when national output grows faster than domestic absorption (consumption + investment + government spending) (Alexander 1952). The integration of these theories provides a robust foundation for examining nonlinear and asymmetric exchange rate effects.

Empirical evidence for Nigeria remains mixed. Some studies find that depreciation improves trade balance in the long run (Ijirshar *et al*., 2022; Duru *et al*., 2022), while others report short-run deterioration consistent with the J-Curve hypothesis (Akighir, 2023). More recent studies using NARDL techniques reveal asymmetric effects, where appreciation may worsen trade balance more strongly than depreciation improves it (Bahmani-Oskooee & Aftab, 2017; Sambo *et al*., 2021; Rasaki & Oyedepo, 2023).

The literature on exchange rate and trade balance spans three strands: theory, linear evidence, and nonlinear analysis. The Marshall–Lerner condition and J-Curve hypothesis explain trade responses, while early linear studies show mixed short- and long-run effects (Magee,1997). Later studies highlight volatility-induced uncertainty. Recent NARDL-based evidence confirms asymmetric effects, with appreciation exerting stronger impacts (Rasaki & Oyedepo, 2023). However, few studies jointly examine volatility and asymmetry, a gap this study addresses.

Empirical evidence on exchange rate volatility and trade balance shows mixed results across countries. For instance, De Grauwe (1988) finds that volatility may increase trade under risk diversification, while Bollerslev (1986) demonstrates that volatility clustering significantly affects financial and trade variables. In sub-Saharan Africa, studies show that exchange rate instability reduces export performance due to weak financial systems and limited hedging instruments (Fofanah, 2024; Akanbi *et al*., 2024).

Recent empirical studies have moved beyond early elasticity-based approaches to provide more current evidence on the exchange rate–trade balance relationship. Using advanced time-series and nonlinear techniques, studies such as Bahmani-Oskooee and Aftab (2017), Sambo *et al*. (2021),

and Ayomitunde *et al*. (2018) show that exchange rate depreciation does not consistently improve trade balance, especially in developing economies with structural rigidities. In the Nigerian context, Rasaki and Oyedepo (2023) and Sambo *et al*. (2021) report that while depreciation has limited or insignificant effects, exchange rate appreciation significantly worsens trade balance. These findings suggest that the traditional assumption of predictable improvement in trade balance following depreciation is no longer robust, thereby justifying the use of nonlinear and asymmetric modelling approaches.

With the collapse of the Bretton Woods system and the adoption of flexible exchange rate regimes, attention shifted from exchange rate levels to exchange rate volatility. Clark (1973) was among the first to argue that exchange rate volatility introduces uncertainty, which may discourage international trade if firms are risk-averse.

Subsequent empirical studies produced mixed results on the effect of exchange rate volatility on trade performance. While De Grauwe (1988) argues that volatility may either reduce or enhance trade depending on firms' risk preferences and hedging capacity, other studies find differing outcomes across countries and periods. Using ARCH/GARCH models, Bollerslev (1986) provides improved measurement of time-varying exchange rate uncertainty, further revealing that the impact of volatility on trade is not uniform but context-dependent.

Empirical findings across developing countries remain inconclusive. Some studies report that exchange rate volatility reduces exports and worsens trade balance due to heightened uncertainty and transaction costs (Fofanah, 2024; Akanbi *et al*., 2024). Others (such as Bahmani-Oskooee & Hegerty, 2007) find insignificant or even positive effects, arguing that volatility may create profit opportunities for risk-neutral traders. These inconsistencies underscore the need for country-specific investigation, particularly for structurally vulnerable economies such as Nigeria.

Several studies on Nigeria employed linear ARDL and cointegration frameworks to test the impact of exchange rate movements on trade balance. Ijirshar *et al*. (2022) found that real exchange rate depreciation satisfies the Marshall–Lerner condition in the long run. Their results indicate that sustained depreciation improves Nigeria's trade balance once adjustment processes are completed. Similarly, Duru *et al*. (2022) tested both the Marshall–Lerner condition and the J-Curve hypothesis. They found weak evidence of short-run deterioration but significant long-run improvement in trade balance following depreciation.

Chinweuba (2025), using ARDL methodology, reported a significant long-run relationship between exchange rate dynamics and Nigeria's balance of payments. The study identified exchange rate and trade openness as major drivers of external sector performance. While these studies confirm long-run cointegration, they largely assume symmetric responses and do not explicitly account for volatility effects.

Esomnofu and Okpalanwabude (2025) found that exchange rate volatility significantly worsens Nigeria's trade balance. Their findings suggest that domestic industries lack competitiveness and depend heavily on imported inputs, making volatility particularly harmful. Irmiya *et al*. (2023) reported that exchange rate fluctuations significantly disrupted Nigeria's balance of payments between 2010 and 2019. Increased volatility weakened the naira, discouraged exports, and increased import costs. Akatugba (2018) similarly found that exchange rate volatility negatively affects Nigeria's balance of payments, suggesting that persistent instability undermines external sector sustainability. These studies confirm the relevance of the uncertainty channel but generally rely on linear specifications.

Recent literature increasingly challenges the assumption of symmetric effects. Shin *et al.* (2014) introduced the Nonlinear ARDL (NARDL) framework, allowing positive and negative changes in exchange rate to exert different effects. Bahmani-Oskooee and Aftab (2017) showed that appreciation and depreciation affect trade flows asymmetrically across countries. Chien *et al.* (2020) and Xu *et al*. (2022) further confirmed asymmetric responses in emerging markets. For Nigeria, Rasaki and Oyedepo (2023) employed NARDL and found significant asymmetric effects of exchange rate volatility on trade flows. Their findings suggest that currency appreciation

worsens trade balance more strongly than depreciation improves it. Sambo *et al*. (2021) also documented nonlinear relationships between exchange rate volatility and trade balance, emphasizing the importance of modeling asymmetry. Akighir (2023), using a structural VAR model, found partial support for the J-Curve hypothesis, with initial deterioration followed by long-run improvement. These studies demonstrate that ignoring asymmetry may lead to biased conclusions.

Moreover, Nigeria's increasing import dependence and limited export diversification suggest that positive and negative volatility shocks may produce different magnitudes of response, necessitating asymmetric modeling. However, findings for Nigeria remain inconclusive due to differences in methodology, model specification, and volatility measurement. By addressing these gaps, the study provides a more comprehensive and policy-relevant understanding of exchange rate–trade balance dynamics in Nigeria.

METHODOLOGY

This study underpinned by the Absorption Theory, developed by Alexander (1952), posits that a country's trade balance is determined by the difference between national output (Y) and domestic absorption (A), where absorption represents total domestic expenditure (consumption + investment + government spending). The theory suggests that a trade surplus occurs when output exceeds domestic absorption (Y > A), while a deficit arises when absorption exceeds output (A > Y). In relation to this study, exchange rate depreciation is expected to improve trade balance only if it leads to an increase in domestic production relative to domestic expenditure.

However, in an import-dependent economy like Nigeria where production relies heavily on imported inputs, depreciation may increase production costs and domestic prices, thereby raise absorption and weaken the expected improvement in trade balance. This theoretical provision justifies the inclusion of macroeconomic variables such as GDP and trade openness, as they influence the relationship between output, absorption, and external balance.

Following the Absorption Theory, trade balance (TB) is functionally expressed as:

$$TB = f(RER) \quad (1)$$

Where;

TB = Trade Balance
RER = Exchange Rate Volatility

Inflation, gross domestic product and trade openness are widely used in the existing literature (see Ijirshar *et al*., 2022; Duru *et al*., 2022) as control variables in the nexus between exchange rate volatility and trade balance. Therefore, this study used inflation, gross domestic product and trade openness as control variables, and Equation 1 is expressed further as

$$TB_t = f(\text{RER}, GDP_t, INF_t, OPEN_t) \quad (2)$$

The econometric model is specified as:

$$TB_t = \beta_0 + \beta_1 RER_t + \beta_2 GDP_t + \beta_3 INF_t + \beta_4 OPEN_t + \varepsilon_t \quad (3)$$

Where;

TB = Trade Balance,
RER = Real Exchange Rate,
GDP = Gross Domestic Product,
INF = Inflation,
OPEN = Trade Openness, and
ε = Error Term

A priori expectations are as follows: exchange rate depreciation is expected to improve trade balance (+), although this may be weak in import-dependent economies; inflation is expected to negatively affect trade balance (−); GDP may have ambiguous effects depending on import dependence; and trade openness is expected to positively influence trade balance (+) through export expansion.

The study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model developed by Shin *et al*. (2014). The NARDL model decomposes exchange rate volatility into positive and negative partial sums:

- RER^+= Positive changes in volatility
- RER^-= Negative changes in volatility

This allows examination of asymmetric effects. The Nonlinear ARDL (NARDL) model developed by Shin and Greenwood-Nimmo (2014) captures both short-run and long-run dynamics simultaneously, is

suitable for small sample sizes, accommodates variables with mixed integration orders I(0) and I(1), and explicitly models asymmetry in the relationship among variables.

Quarterly data covering Q1 1990 – Q4 2025 were sourced from IMF International Financial Statistics (Exchange Rate, GDP and inflation), and National Bureau of Statistics (Trade balance and Trade Openness).

Trade balance was measured as export minus import. Exchange rate was proxied by real exchange rate. Inflation was measured as annual consumer price index. Trade openness was measured as export plus import divided by GDP. GDP is proxied as real GDP.

RESULTS AND DISCUSSION

This section presents and discusses the empirical findings of the study. The results include descriptive statistics, unit root tests, cointegration analysis, ARDL short-run and long-run estimates, bounds test, nonlinear ARDL results, and diagnostic tests. These results provide empirical evidence on the relationship between exchange rate dynamics and trade balance in Nigeria.

The descriptive statistics of the variables used in the model are presented in Table 1. The variables include inflation (INF), economic growth measured by the real GDP (GDP), trade balance (TB), trade openness (OPEN) measured by export plus import divided by GDP, and real exchange rate (RER).

Table 1: Descriptive Statistic Result

	INF	GDP	TB	OPEN	RER
Mean	30.35624	1307237.	1.31E+11	16.94577	205.5834
Median	29.57947	901071.5	2.90E+09	0.002629	100.2597
Maximum	66.02561	7463965.	1.22E+12	83.68477	1310.983
Minimum	11.20000	-1890256.	1.88E+09	1.23E-05	30.34920
Std. Dev.	10.38227	1522439.	3.48E+11	22.25740	250.2058
Skewness	0.931243	1.569778	2.362035	0.960019	2.695333
Kurtosis	4.298824	5.977223	6.654384	2.765007	11.20753
Jarque-Bera	26.63828	96.72347	184.3020	19.33247	498.1844
Probability	0.000002	0.000000	0.000000	0.000063	0.000000
Sum	3764.174	1.62E+08	1.62E+13	2101.276	25492.34
Sum Sq. Dev.	13258.36	2.85E+14	1.49E+25	60933.22	7700162.
Observations	124	124	124	124	124

Where; INF = inflation, LNGDP = economic growth, LNTB = Trade balance, OPEN = trade openness, and RER = real exchange rate

The results show that inflation has a mean value of 30.36%, indicating persistent inflationary pressures in Nigeria over the study period. The relatively high standard deviation (10.38) suggests noticeable fluctuations in price levels, which may affect macroeconomic stability and external competitiveness. Real GDP records a large mean value of 1,307,237 with a high standard deviation of 1,522,439, indicating significant variability in economic activity. The negative minimum value reflects periods of economic contraction, likely associated with external shocks such as oil price fluctuations.

Trade balance (TB) exhibits a high mean value of 1.31E+11, suggesting that Nigeria maintained a trade surplus on average during the study period. However, the wide gap between the minimum (1.88E+09) and maximum (1.22E+12), alongside a large standard deviation (3.48E+11), indicates substantial volatility in trade performance over time. Trade openness (OPEN) has an average value of 16.95, reflecting Nigeria's level of integration into global trade. The high standard deviation (22.26) implies considerable fluctuations in trade intensity, likely driven by changes in trade policy, exchange rate movements, and global economic conditions.

The real exchange rate (RER) has a mean value of 205.58 and a large standard deviation of 250.21, indicating significant volatility in the value of the

naira. The wide range between the minimum (30.35) and maximum (1310.98) further confirms the extent of exchange rate instability over the period, which may create uncertainty for economic agents engaged in international trade.

The skewness statistics indicate that all variables are positively skewed, suggesting that their distributions are tilted toward higher values. The kurtosis values for GDP, TB, and RER exceed 3, indicating leptokurtic distributions characterized by heavy tails and the presence of extreme values. The Jarque–Bera statistics show that all variables are statistically significant at conventional levels, implying rejection of the null hypothesis of normal distribution. This suggests that the series are not normally distributed, a common feature of macroeconomic time series due to structural breaks and external shocks.

Overall, the descriptive statistics reveal substantial variability and volatility across the variables, particularly in trade balance and exchange rate.

These characteristics justify the application of advanced econometric techniques to capture the dynamic and potentially nonlinear relationships among the variables.

Prior to estimating the econometric models, the stationarity properties of the variables were examined using the Augmented Dickey-Fuller (ADF) unit root test. This test is essential to avoid spurious regression results that may arise when non-stationary time series are used in econometric analysis.

Table 2: Unit Root Test (Augmented Dickey-Fuller)

Series	Level	First Difference	Order of Stationarity
inf	-2.969**	-12.322***	I(0)
gdp	-0.097	-11.167***	I(1)
tb	-3.166**	-10.961***	I(0)
open	-1.693	-12.014***	I(1)
rer	-8.540***	-6.826***	I(0)

***, *** indicate significance level at 5% and 1% respectively*

The results show that inflation (INF), trade balance (TB), and real exchange rate (RER) are stationary at level, implying that they are integrated of order zero, I (0). In contrast, economic growth (GDP) and trade openness (OPEN) become stationary only after first differencing, indicating that they are integrated of order one, I (1). The presence of both I (0) and I (1) variables confirms the suitability of the Autoregressive Distributed Lag (ARDL) modelling approach. One of the major advantages of the ARDL technique is its ability to accommodate variables with mixed orders of integration, provided that none of the variables is integrated of order two. This result also implies that the variables may share a long-run equilibrium relationship despite their different orders of integration, which necessitates the implementation of cointegration tests.

To determine whether a long-run equilibrium relationship exists among the variables, the Johansen cointegration test was employed. The results are presented in Table 3.

Table 3: Cointegration Test

Hypothesized		Trace	0.05		Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**	No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.350391	77.94411	69.81889	0.0097	None *	0.350391	51.33482	33.87687	0.0002
At most 1	0.109684	26.60929	47.85613	0.8686	At most 1	0.109684	13.82522	27.58434	0.8345
At most 2	0.058594	12.78407	29.79707	0.9012	At most 2	0.058594	7.185267	21.13162	0.9463
At most 3	0.045909	5.598802	15.49471	0.7423	At most 3	0.045909	5.592599	14.26460	0.6659
At most 4	5.21E-05	0.006203	3.841466	0.9367	At most 4	5.21E-05	0.006203	3.841466	0.9367

The trace test indicates the existence of one cointegrating equation at the 5% significance level. Specifically, the trace statistic of 77.94 exceeds the critical value of 69.82, leading to rejection of the null hypothesis of no cointegration. Similarly, the maximum eigenvalue test confirms the presence of one cointegrating relationship, as the calculated statistic of 51.33 is greater than the critical value of 33.88. The presence of cointegration implies that the variables move together in the long-run despite short-run fluctuations. In other words, there exists a stable equilibrium relationship between trade balance and its determinants, including exchange rate movements, inflation, economic growth, and trade openness. This finding supports theoretical expectations derived from international trade theory, particularly the absorption theory and the uncertainty theory, which emphasize the long-run interaction between exchange rate dynamics and external sector performance.

The short-run dynamics of the relationship between exchange rate variables and trade balance are estimated using the ARDL error correction framework. The results are reported in Table 4.

Table 4: ARDL Error Correction Regression

Dependent Variable: LNTB				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LNTB(-1))	-0.217087	0.086990	-2.495544	0.0141
D(LNTB(-2))	-0.151147	0.082688	-1.827916	0.0703
D(OPEN)	0.003843	0.001684	2.282266	0.0244
D(OPEN(-1))	-0.000924	0.001631	-0.566198	0.5724
D(OPEN(-2))	-0.006265	0.001626	-3.853741	0.0002
D(OPEN(-3))	-0.005266	0.001782	-2.955866	0.0038
CointEq(-1)*	-0.250440	0.056727	-4.414851	0.0000
R-squared	*0.311629*	*Durbin-Watson stat*		*1.916844*

The coefficient of the first lag of trade balance D(LNTB(-1)) is negative and statistically significant, indicating that past deviations in trade balance influence the current period and that shocks persist before gradual adjustment occurs. This finding is consistent with dynamic adjustment models in the literature, particularly studies such as Duru *et al.* (2022), which report sluggish adjustment of trade balance due to structural rigidities and delayed response of exports and imports. It also aligns with the J-Curve hypothesis, which suggests that trade balance does not adjust immediately to shocks.

Trade openness exhibits mixed short-run effects on trade balance. The contemporaneous positive and significant coefficient implies that increased openness initially improves trade balance through export expansion, supporting findings by Ijirshar *et al.* (2022). However, the negative and significant lagged effects indicate that openness subsequently increases import demand, thereby worsening trade balance. This pattern is consistent with evidence from developing economies where trade liberalization stimulates both exports and imports. The divergence from strictly positive effects can be explained by Nigeria's high import dependence and weak domestic industrial base, which limit the sustainability of export gains.

The error correction term CointEq(-1) is negative and statistically significant, confirming the existence of a stable long-run equilibrium relationship among the variables. The coefficient (–0.2504) indicates that approximately 25% of short-run disequilibrium is corrected within one period, implying a moderate speed of adjustment. This result is consistent with prior ARDL-based studies such as Bahmani-Oskooee and Ratha (2004), which document partial and gradual adjustment toward equilibrium in trade models. The relatively slow adjustment speed may reflect structural bottlenecks, including infrastructural deficits and reliance on imports, which delay the transmission of exchange rate effects to trade balance.

The long-run coefficients of the ARDL model are presented in Table 5.

Table 5: ARDL Long Run Form

Dependent Variable: LNTB				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.088676	0.170461	0.520214	0.6040
LNTB(-1)*	-0.250440	0.065112	-3.846303	0.0002
RER**	1.24E-05	8.65E-05	0.143660	0.8860
LNGDP**	-0.000767	0.015473	-0.049544	0.9606
INF**	-0.001693	0.001268	-1.334597	0.1848
OPEN(-1)	0.002570	0.000783	3.281641	0.0014
D(LNTB(-1))	-0.217087	0.092341	-2.350928	0.0205
D(LNTB(-2))	-0.151147	0.086437	-1.748637	0.0832
D(OPEN)	0.003843	0.001798	2.137398	0.0348
D(OPEN(-1))	-0.000924	0.001693	-0.545628	0.5864
D(OPEN(-2))	-0.006265	0.001690	-3.707385	0.0003
D(OPEN(-3))	-0.005266	0.001841	-2.860860	0.0051

Table 6: Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Sig.	I(0) Asymptotic: n=1000	I(1)
F-statistic	3.104746	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

The results show that trade openness has a positive and statistically significant impact on trade balance in the long run, indicating that greater integration into global trade enhances Nigeria's external sector performance. This finding supports studies such as Ijirshar *et al*. (2022) and Chinweuba (2025), which also report a positive contribution of openness through export expansion. However, it contrasts with some developing-country evidence where openness worsens trade balance due to import surges. The positive outcome here may be explained by periods in which export earnings, particularly from crude oil, outpaced import growth.

The real exchange rate exhibits a positive but statistically insignificant effect on trade balance, suggesting that exchange rate movements alone are not a strong determinant of trade performance in Nigeria. This result aligns with recent nonlinear evidence such as Rasaki and Oyedepo (2023) and Sambo *et al*. (2021), which report weak or insignificant effects of depreciation. However, it contradicts the traditional expectation of the Marshall–Lerner condition. A plausible explanation is Nigeria's export structure, which is heavily dominated by crude oil with relatively inelastic demand, thereby limiting the responsiveness of trade balance to exchange rate changes.

Economic growth shows a negative but statistically insignificant relationship with trade balance, supporting the import-dependent growth hypothesis. This finding is consistent with Duru *et al*. (2022), who argue that increased economic activity in Nigeria often leads to higher demand for imported capital and intermediate goods. The insignificant effect suggests that growth has not translated into export diversification or competitiveness, reflecting structural weaknesses in the economy. Similarly, inflation has a negative but insignificant effect on trade balance, which is consistent with theoretical expectations and empirical findings such as Akanbi *et al*. (2024), where higher inflation reduces international competitiveness. However, the lack of statistical significance indicates that inflation may not be a dominant driver of trade balance compared to structural factors like exchange rate management and export composition. This suggests that macroeconomic instability alone does not fully explain trade performance in Nigeria.

To capture possible nonlinear effects of exchange rate movements on trade balance, the study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model.

Table 7: NARDL Result

Dependent Variable: LNTB				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNTB(-1)	0.600193	0.068790	8.724956	0.0000
RER_POS	-0.001641	0.000691	-2.373900	0.0194
RER_NEG	-0.000127	0.000101	-1.258026	0.2111
LNGDP	0.016459	0.018455	0.891864	0.3744
INF	-0.001232	0.001294	-0.951905	0.3433
OPEN	0.003363	0.001797	1.871568	0.0639
OPEN(-1)	-0.002185	0.002237	-0.976974	0.3307
OPEN(-2)	-0.005299	0.002190	-2.419412	0.0172
OPEN(-3)	0.001562	0.002280	0.685130	0.4947
OPEN(-4)	0.004727	0.001803	2.621095	0.0100
C	-0.057652	0.201453	-0.286182	0.7753
Adjusted R^2	*0.763563*	*Durbin-Watson stat*		*2.069346*
F-statistic	*39.43049*	*Prob(F-statistic)*		*0.000000*

The results reveal significant asymmetric effects in the exchange rate–trade balance relationship. Positive changes in exchange rate (appreciation) have a negative and statistically significant impact on trade balance, implying that appreciation worsens trade performance by making imports cheaper and exports less competitive. This finding is consistent with recent nonlinear evidence such as Bahmani-Oskooee and Aftab (2017), as well as Rasaki and Oyedepo (2023), who report that appreciation exerts a stronger adverse effect on trade balance in developing economies.

In contrast, negative changes in exchange rate (depreciation) are statistically insignificant, suggesting that depreciation does not significantly improve trade balance. This result supports studies such as Sambo *et al*. (2021), but contradicts traditional expectations based on the Marshall–Lerner condition. A plausible explanation lies in Nigeria's structural characteristics, particularly its

heavy dependence on imports and limited export diversification. Depreciation may increase the cost of imported inputs, raise production costs, and offset any potential gains from improved export competitiveness.

Overall, these asymmetric findings reinforce the growing body of literature, including Greenwood-Nimmo (2014), which emphasizes that exchange rate movements do not affect trade balance uniformly. The results therefore justify the use of nonlinear modelling approaches as linear models may mask these important differential effects.

The NARDL dynamic multiplier graph illustrates how trade balance responds to positive and negative exchange rate shocks over time.

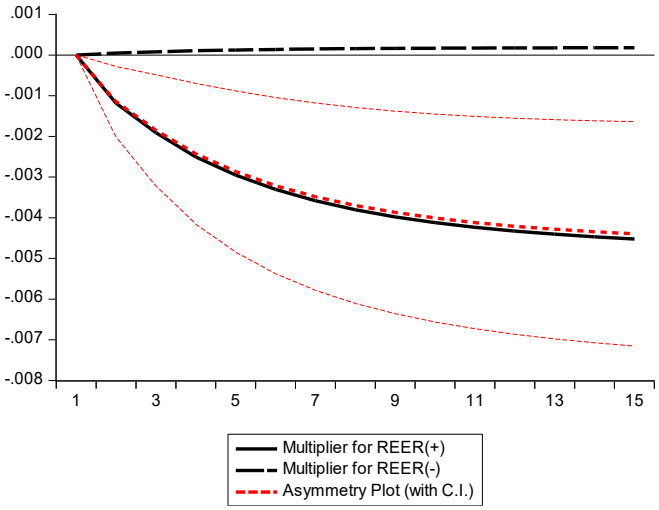

Figure 1: NARDL Multiplier Graph

The results indicate that positive exchange rate shocks generate stronger and more persistent effects on trade balance compared with negative shocks, confirming the presence of asymmetric adjustment dynamics in Nigeria's trade sector. This finding is consistent with nonlinear empirical evidence, particularly the NARDL framework proposed by Greenwood-Nimmo (2014), and supported by studies such as Bahmani-Oskooee and Aftab (2017), and Rasaki and Oyedepo (2023), which show that exchange rate appreciations tend to have more pronounced and lasting adverse effects than depreciations. However, this outcome deviates from traditional symmetric models that assume equal adjustment to positive and negative shocks. A credible explanation lies in Nigeria's structural characteristics, including high import dependence and limited export diversification, which amplify the adverse impact of appreciation while constraining the potential gains from depreciation. This asymmetry underscores the importance of adopting nonlinear approaches in analyzing exchange rate–trade balance dynamics.
Several diagnostic tests were conducted to verify the reliability and robustness of the estimated model.

Table 8: Diagnostic Tests

	F-statistic	P-value
Ramsey RESET Test	1.967750	0.1636
LM Test	1.485213	0.2311
Heteroskedasticity Test: ARCH	8.691192	0.0039

The Ramsey RESET test indicates that the model is correctly specified since the probability value exceeds the 5 percent significance level. The Breusch–Godfrey LM test reveals the absence of serial correlation in the residuals, suggesting that the model is free from autocorrelation problems. However, the ARCH test indicates the presence of heteroskedasticity in the residuals, suggesting that the variance of the error terms changes over time. This result reflects the volatility of macroeconomic variables in Nigeria. The CUSUM stability test confirms that the estimated parameters remain stable over the sample period, as the cumulative sum of recursive residuals lies within the critical bounds.

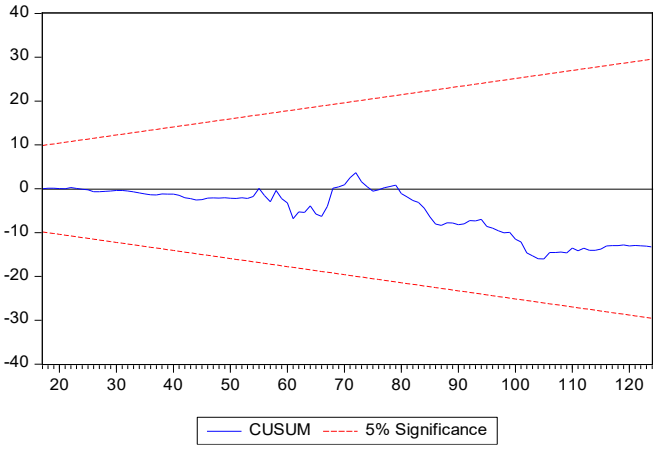

Figure 2: Stability Test

CONCLUSION

This study investigated the impact of exchange rate volatility on Nigeria's trade balance using ARDL and NARDL modelling techniques. The results confirm the existence of a long-run equilibrium

relationship between trade balance and its key macroeconomic determinants. The findings reveal that trade openness significantly improves trade balance in the long run, while exchange rate movements exhibit asymmetric effects. Exchange rate appreciation significantly worsens trade balance, whereas depreciation does not significantly improve it. These results suggest that exchange rate depreciation alone may not be sufficient to improve Nigeria's trade balance due to the country's structural dependence on imports and limited export diversification.

Based on the finding that exchange rate appreciation significantly worsens trade balance, monetary authorities should prioritize exchange rate stability through effective foreign exchange management and policy coordination. This can be achieved by reducing speculative pressures and improving foreign reserve management. Given that depreciation does not significantly improve trade balance, Nigeria should diversify its export base beyond crude oil by promoting non-oil sectors such as manufacturing and agriculture through targeted industrial policies and export incentives. Since trade openness positively influences trade balance in the long run, government should enhance trade facilitation by improving infrastructure, reducing port inefficiencies, and eliminating bureaucratic bottlenecks. Finally, the insignificant effect of macroeconomic variables such as inflation and GDP suggests structural weaknesses; therefore, strengthening domestic production capacity through investment in local industries will reduce import dependence and improve external sector performance.

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