 http://dx.doi.org/10.18623/rvd.v23.n4.4939

ANOTHER LOOK AT THE EXCHANGE RATE FLUCTUATIONS ON REAL SECTOR PRODUCTIVITY IN NIGERIA

OUTRA PERSPECTIVA SOBRE AS FLUTUAÇÕES DA TAXA DE CÂMBIO NA PRODUTIVIDADE DO SETOR REAL NA NIGÉRIA

Article received on: 10/16/2025
Article accepted on: 1/16/2026

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The authors declare that there is no conflict of interest

Abstract
This study examines the effects of exchange rate fluctuations on real sector productivity in Nigeria, focusing on the agricultural and industrial sectors over the period 1991–2024. The study is motivated by persistent exchange rate instability and inconclusive empirical evidence on its implications for sectoral productivity. The study employs the Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) techniques to capture both dynamic and asymmetric relationships between exchange rate movements and sectoral productivity, following unit root and bounds tests for cointegration. The results reveal stable long-run relationships between exchange rate movements and sectoral productivity. Exchange rate depreciation has a positive and significant long-run effect on agricultural and industrial productivity, with asymmetric effects more pronounced in the industrial sector. Short-run exchange rate effects are largely insignificant, reflecting adjustment costs and delayed investment responses. The study concludes that exchange rate fluctuations influence real sector productivity mainly through long-run and asymmetric channels. It therefore

Resumo
Este estudo examina os efeitos das flutuações da taxa de câmbio sobre a produtividade do setor real na Nigéria, com foco nos setores agrícola e industrial no período de 1991–2024. O estudo é motivado pela persistente instabilidade cambial e pelas evidências empíricas inconclusivas quanto às suas implicações para a produtividade setorial. A pesquisa utiliza as técnicas de Autorregressão com Defasagens Distribuídas (ARDL) e ARDL Não Linear (NARDL) para captar tanto as relações dinâmicas quanto as assimétricas entre os movimentos da taxa de câmbio e a produtividade setorial, após a realização de testes de raiz unitária e de limites para cointegração. Os resultados revelam relações estáveis de longo prazo entre os movimentos da taxa de câmbio e a produtividade setorial. A depreciação cambial apresenta um efeito positivo e significativo de longo prazo sobre a produtividade agrícola e industrial, sendo os efeitos assimétricos mais pronunciados no setor industrial. No curto prazo, os efeitos da taxa de câmbio são, em grande parte, insignificantes, refletindo custos de ajustamento e respostas tardias do investimento. O estudo conclui que as flutuações

recommends prioritising exchange rate stability and policy consistency, alongside sector-specific measures to strengthen domestic productive capacity and reduce import dependence for sustainable productivity growth in Nigeria.

Keywords: Exchange Rate. Agricultural Productivity. Industrial Productivity. Nigeria. ARDL. NARDL.

cambiais influenciam a produtividade do setor real principalmente por meio de canais de longo prazo e assimétricos. Recomenda-se, portanto, a priorização da estabilidade cambial e da consistência das políticas económicas, juntamente com medidas específicas para cada setor, a fim de fortalecer a capacidade produtiva interna e reduzir a dependência de importações para um crescimento sustentável da produtividade na Nigéria.

Palavras-chave: *Taxa de Câmbio. Produtividade Agrícola. Produtividade Industrial. Nigéria. ARDL. NARDL.*

1 INTRODUCTION

Exchange rate movements play a fundamental role in shaping economic growth and productivity across the global economy. By influencing relative prices, exchange rates affect export competitiveness, import costs, investment decisions, and production efficiency, thereby linking the external sector to domestic productive activity. Han (2020) argues that exchange rate fluctuations affect growth primarily through trade and investment channels, while Ramoni-Perazzi and Romero (2022) show that heightened exchange rate instability weakens growth by increasing macroeconomic uncertainty. Similarly, Ridhwan *et al*. (2024) demonstrate through meta-analysis that real exchange rate depreciation can stimulate growth, particularly in developing economies, though outcomes vary across contexts. Evidence from emerging economies further indicates that unstable exchange rate movements often discourage productivity-enhancing investment, especially in sectors dependent on imported inputs (Usman, 2023).

Recent global studies increasingly emphasise that the exchange rate–growth relationship is complex, nonlinear, and asymmetric. Using nonlinear frameworks, Iqbal *et al*. (2023) reveal that exchange rate misalignment affects economic growth differently depending on whether the currency is overvalued or undervalued. In support, Ramoni-Perazzi and Romero (2022) show that the adverse growth effects of exchange rate instability diminish as financial systems deepen, suggesting that structural characteristics mediate exchange rate impacts. Han (2020) further notes that the magnitude of exchange rate effects varies across countries due to differences in openness and investment structures, while Usman (2023) highlights frequency-dependent causal links between exchange rates, trade, and output. These findings underscore the need for empirical models capable of capturing both dynamic and asymmetric exchange rate behaviour.

In Africa, exchange rate fluctuations are particularly consequential due to the continent's high exposure to external shocks, reliance on commodity exports, and dependence on imported intermediate and capital goods. Oppong *et al*. (2026) identify the exchange rate as a dominant transmitter of macroeconomic shocks in Ghana, especially during crisis periods. Similarly, Odoom *et al*. (2025) find that exchange rate shocks interact strongly with public debt and inflation, amplifying growth instability. In Ethiopia, Malec *et al*. (2024) show that exchange rate depreciation constrains economic growth by raising import costs and limiting productive capacity, while Hordofa (2023) reports nonlinear exchange rate effects that discourage long-term investment. Together, these studies highlight the fragility of African real sectors to exchange rate instability.

Beyond aggregate growth effects, African evidence also suggests that exchange rate impacts vary across time horizons and productive sectors. Using time- and frequency-domain techniques, Odoom *et al*. (2025) demonstrate that exchange rate effects differ in the short, medium, and long run, reinforcing the importance of dynamic modelling. Oppong *et al*. (2026) similarly find that exchange rate spillovers intensify during periods of economic stress. Malec *et al*. (2024) observe that sustained depreciation reduces access to imported inputs necessary for production, while Hordofa (2023) shows that uncertainty surrounding exchange rate movements weakens productivity-driven investment. These findings justify sector-specific and time-sensitive analyses of exchange rate effects in African economies.

Nigeria presents a particularly compelling case for examining exchange rate fluctuations and real sector productivity. The country has experienced persistent exchange rate instability driven by oil revenue volatility, foreign exchange shortages, and frequent policy shifts. Ehikioya (2019) finds that exchange rate volatility has a negative and significant effect on Nigeria's economic growth, reflecting heightened uncertainty. Similarly, Ikechi and Nwadiubu (2020) document instability in Nigeria's real effective exchange rate with adverse implications for trade performance. While Miftahu and Shuyur (2023) report a positive but insignificant effect of exchange rate movements on growth, Jacob and Rosemary (2022) show that inflation and exchange rate instability weaken output performance. These mixed outcomes signal unresolved empirical questions.

Sector-level evidence for Nigeria further reveals heterogeneous responses of the real sector to exchange rate fluctuations. Ayobami (2019) finds that exchange rate movements positively affect manufacturing output in the short and long run, though imports exert a negative influence. In contrast, Adebanjo *et al*. (2019) show that naira depreciation negatively affects manufacturing performance due to higher production costs. Using nonlinear techniques, Uche and Nwamiri (2021) reveal asymmetric effects in which exchange rate depreciation retards productivity in the short run. More recently, Ezenwaka *et al*. (2025) demonstrate that while exchange rate levels may support manufacturing value-added and employment, exchange rate shocks reduce manufacturing output and exports. Ogunjimi (2019) further confirms that sectoral responses differ across agriculture, industry, and services.

The central problem motivating this study is that, despite sustained exchange rate reforms, Nigeria's real sector productivity remains weak and uneven. Agricultural output growth has been modest, industrial performance has remained fragile, and exchange rate instability continues to heighten production uncertainty. Although Gimba *et al*. (2025) show that exports can enhance growth when moderated by exchange rate movements, imports exert a negative effect, reflecting structural dependence on foreign inputs. Ehikioya (2019) and Uche and Nwamiri (2021) further argue that exchange rate instability undermines productivity gains, while Ezenwaka *et al*. (2025) highlight the damaging role of exchange rate shocks. These inconsistencies indicate gaps in sector-specific, asymmetric, and updated empirical evidence.

This study therefore examines the effects of exchange rate fluctuations on real sector productivity in Nigeria over the period 1991–2024, employing a disaggregated analytical framework. The relationships between exchange rate movements and manufacturing output and agricultural output are estimated separately using ARDL and NARDL techniques to capture both linear and asymmetric effects. By extending the data to recent years and explicitly accounting for asymmetric adjustment dynamics, this study contributes to the literature and offers policy-relevant insights for exchange rate management, industrial development, and sustainable productivity growth in Nigeria (Ayobami, 2019; Uche & Nwamiri, 2021; Ridhwan *et al*., 2024; Gimba *et al*., 2025).

2 LITERATURE REVIEW

The present study is anchored on the Investment Uncertainty Theory, originally advanced by Bernanke (1983) and later formalised within the real options framework by Dixit and Pindyck (1994). The theory posits that when firms face heightened uncertainty—such as unstable exchange rate movements—they tend to delay or scale down irreversible investment decisions because expenditures on machinery, technology, and capacity expansion cannot be easily reversed. In an open economy, exchange rate instability increases uncertainty about future input costs, export earnings, and profitability, thereby weakening investment incentives and productivity growth. Empirical evidence supports this mechanism: Ramoni-Perazzi and Romero (2022) show that exchange rate instability significantly depresses economic growth by raising uncertainty, while Ehikioya (2019) finds that persistent exchange rate instability undermines Nigeria's growth performance. Consistent with this, Uche and Nwamiri (2021) demonstrate that exchange rate depreciation retards productivity in the short run, reflecting firms' cautious response to uncertain macroeconomic conditions.

Anchoring this study on the Investment Uncertainty Theory is further justified by its strong alignment with the study's sectoral focus and estimation strategy. Agricultural and industrial productivity are both highly sensitive to investment decisions and cost conditions, which are influenced by exchange rate movements. Evidence for Nigeria shows that exchange rate instability significantly affects manufacturing performance (Ayobami, 2019), while exchange rate shocks reduce manufacturing value-added, exports, and employment (Ezenwaka *et al*., 2025). Similarly, Gimba *et al*. (2025) demonstrate that exchange rate movements moderate the trade–growth relationship, underscoring uncertainty as a key transmission channel. By employing ARDL and NARDL frameworks to capture dynamic and asymmetric effects of exchange rate movements, this study provides a theoretically consistent and empirically robust application of the Investment Uncertainty Theory in analysing how exchange rate fluctuations influence real sector productivity in Nigeria over the period 1991–2024.

Empirical evidence from Nigeria and other developing economies suggests that exchange rate fluctuations exert significant influence on macroeconomic performance, particularly through trade, productivity, and output channels. For Nigeria, Gimba *et al*.

(2025) examined the moderating role of exchange rate volatility in the trade–growth nexus using TGARCH and ARDL techniques and found that exports enhance economic growth when moderated by exchange rate volatility, while imports exert a negative effect. Similarly, Ikechi and Nwadiubu (2020) established that exchange rate volatility significantly affects export and import dynamics in Nigeria, with volatility clustering around real effective exchange rate movements. Supporting this, Bicudo and Azu (2018), Jacob and Rosemary (2022) and Miftahu and Shuyur (2023) reported that exchange rate movements positively influence economic growth in Nigeria in the short run, though excessive fluctuations undermine long-run stability. These findings collectively indicate that while exchange rate movements can stimulate trade-led growth, heightened volatility poses risks to sustained productivity and output expansion.

Beyond Nigeria, studies from other developing and emerging economies reinforce the destabilising role of exchange rate volatility on growth and productive activities. Using panel data for 194 countries, Ramoni-Perazzi and Romero (2022) found that exchange rate volatility has a consistently negative effect on economic growth, particularly in economies with weak financial systems. In Ethiopia, Malec *et al*. (2024) employed an ARDL framework and demonstrated that both inflation and exchange rate depreciation negatively affect economic growth by constraining imports of intermediate goods critical for production. Similarly, Hordofa (2023) revealed that exchange rate effects on growth are nonlinear and context-dependent, with uncertainty discouraging long-term investment and productive capacity expansion. Complementing these results, Han (2020) showed that exchange rate fluctuations influence growth differently across countries, with stronger effects transmitted through investment channels than trade. Overall, the international evidence suggests that exchange rate instability undermines productive capacity, especially in import-dependent economies.

A growing strand of literature focuses specifically on the real sector, particularly manufacturing and agriculture, which are highly sensitive to exchange rate movements. For Nigeria, Ayobami (2019) found that exchange rate volatility positively and significantly affects manufacturing output in both the short and long run, though imports negatively affect sectoral performance. In contrast, Adebanjo *et al*. (2019) and Ehikioya (2019) reported that exchange rate depreciation and volatility exert negative effects on manufacturing performance and overall economic growth, respectively, largely due to rising production costs and imported input dependence. Using nonlinear techniques, Uche and Nwamiri (2021) further showed that exchange rate depreciation retards productivity in the short run, with no significant long-run productivity gains, suggesting structural weaknesses in Nigeria's real sector. Similarly, Ezenwaka *et al*. (2025) found that while exchange rate levels may support manufacturing value-added and employment, exchange rate shocks significantly reduce manufacturing output, exports, and employment. These mixed findings highlight the fragile and asymmetric response of Nigeria's real sector to exchange rate fluctuations.

Recent methodological advancements also reveal asymmetric and time-varying effects of exchange rate movements on economic performance. Using wavelet and frequency-domain approaches, Odoom *et al*. (2025) and Oppong *et al*. (2026) demonstrated that exchange rate shocks act as dominant transmitters of macroeconomic instability in Ghana, with stronger effects during crisis periods. In India, Iqbal *et al*. (2023) found that exchange rate misalignment affects growth asymmetrically, with undervaluation promoting growth while overvaluation hampers it. A comprehensive meta-analysis by Ridhwan *et al*. (2024) further confirmed that real exchange rate depreciation generally favours economic growth in developing countries, though results vary across methodologies and contexts. These studies collectively suggest that the impact of exchange rate fluctuations on productivity and growth is nonlinear, regime-dependent, and sensitive to structural conditions, reinforcing the need for country-specific empirical re-examinations such as the present study on Nigeria.

Despite the expanding empirical literature on exchange rate fluctuations and economic performance, several important gaps remain unresolved, especially for Nigeria and other developing economies. First, although the Investment Uncertainty Theory advanced by Bernanke (1983) and Dixit and Pindyck (1994) provides a strong theoretical basis for understanding how exchange rate instability influences investment behaviour and productivity, many empirical studies continue to focus largely on aggregate economic growth, rather than real sector productivity indicators, thereby masking sector-specific transmission channels (Ehikioya, 2019; Ramoni-Perazzi & Romero, 2022). Second, existing Nigerian studies report mixed and often conflicting evidence on the effects of exchange rate movements on agricultural and manufacturing performance, with results varying across model specifications, sample periods, and productivity proxies, suggesting unresolved issues of asymmetry and structural heterogeneity (Ayobami, 2019; Adebanjo *et al*., 2019; Uche & Nwamiri, 2021; Ezenwaka *et al*., 2025). Third, while recent international studies emphasise nonlinear and asymmetric exchange rate effects, most Nigerian evidence relies on linear approaches that may fail to capture differential responses to exchange rate appreciation and depreciation (Iqbal *et al*., 2023; Odoom *et al*., 2025; Oppong *et al*., 2026). Finally, relatively few studies combine dynamic and asymmetric estimation techniques, such as ARDL and NARDL, with updated data spanning recent periods of pronounced exchange rate instability, leaving both methodological and temporal gaps in the literature (Gimba *et al*., 2025; Han, 2020; Ridhwan *et al*., 2024). These gaps justify a re-examination of the exchange rate–real sector productivity nexus in Nigeria using a disaggregated and asymmetric empirical framework over the period 1991–2024.

3 METHODOLOGY

3.1 Model specification

To examine the impact of exchange rate movements on real sector productivity in Nigeria, the study specifies two sector-specific productivity models: agricultural productivity and industrial productivity. Following the literature, productivity is measured as output per worker, while all variables are expressed in natural logarithms to ensure linearity, reduce heteroscedasticity, and allow elasticity-based interpretation.

$$RSP_t = f\{GDP, EMP, EXC, REM\} \quad (1)$$

where:

> RSP stands for real sector productivity, which is captured in two perspectives: Agricultural Productivity (PAG) and Industrial Productivity (PIN). GDP represents the nominal gross domestic product, EMP is the total employment, which is captured in two perspectives: total employment in agriculture (EAG) and total employment in industry (EIN). EXC stands for exchange rate, and REM represents inflow remittances. Thus, the model is estimated in two forms as follows:

Agricultural Productivity Model:

$$lnPAG_t = \varphi_t + \delta_1 lnGDP_t + \delta_2 lnEAG_t + \delta_3 lnEXC_t + \delta_4 lnREM_t + \varepsilon_t \qquad (2)$$

Industrial Productivity Model:

$$lnPIN_t = \alpha_t + \delta_1 lnGDP_t + \delta_2 lnEIN_t + \delta_3 lnEXC_t + \delta_4 lnREM_t + \mu_t \qquad (3)$$

where:

ε_t and μ_t error terms,
φ and α are constants,
δ_1 to δ_4 are parameters to bes estimated
and t = time period.

The specified models are grounded in productivity theory and the Investment Uncertainty framework, which links macroeconomic conditions to sectoral efficiency through labour utilisation, cost conditions, and external financial inflows. Employment variables (EAG and EIN) are expected to positively influence productivity by enhancing labour input and scale effects in agriculture and industry. The exchange rate (EXC) captures external competitiveness and input cost dynamics; exchange rate depreciation is expected to improve productivity by encouraging domestic production and export-oriented activities. Remittance inflows (REM) are included to capture the role of external finance in easing liquidity constraints, supporting investment, and enhancing productive capacity. The sector-specific specification allows for differential responses across agriculture and industry, while the log-linear form ensures robustness and comparability with existing empirical studies on exchange rate–productivity relationships in developing economies.

Table 1

Variables, Sources and A priori Expectation

Variables	Description/Indicators	Expectation	Sources
Agricultural Productivity (PAG)	The ratio of Agricultural Output per Agricultural Worker: $\frac{Agricultural\ GDP}{Total\ Employment\ in\ Agriculture}$	Dependent	WDI/CBN
Industrial Productivity (PIN)	The ratio of Industrial Output per Industrial Worker: $\frac{Industrial\ GDP}{Total\ Employment\ in\ Industry}$	Dependent	WDI/CBN
Total Employment in Agriculture (EAG)	Total Employment in the Agricultural Sector	Positive (+)	WDI
Total Employment in Industry (EIN)	Total Employment in the Industrial Sector	Positive (+)	WDI
Exchange Rate (EXC)	Nominal Exchange rate	Positive (+)	WDI
Inflow Remittance (REM)	Total Inflow of Remittance	Positive (+)	WDI

Note: All variables are expressed in logarithms. WDI-World Development Index (World Bank); CBN- Central Bank of Nigeria

Sources: Tables Created by the Authors

3.2 Estimation technique

Econometric techniques widely investigate long-run cointegration among variables, including the Engle and Granger (1987) test, Phillips (1995) and Phillips and Hansen (1990) FMOLS technique, Johansen (1991) and Johansen and Juselius (1990) methodologies. Johansen's cointegration, often favoured for its ability to accommodate small sample sizes and multiple cointegration relationships, requires variables to be integrated at the same order—a significant limitation. To address this, the study adopts the Autoregressive Distributed Lag (ARDL) model, known for estimating long- and short-run coefficients in a single equation. As noted by Pesaran and Smith (1995) and Pesaran *et al*. (2001), ARDL resolves issues of serial correlation and endogeneity while handling variables integrated at I(0), I(1), or both. With appropriate lag selection, its bound test approach delivers robust estimates and captures dynamic interactions. Nuhu, Isik and Azu (2020) highlighted its suitability for small samples. Cointegration is established when the F-test exceeds critical bounds or when a negative, significant error correction term (ECM-1) is present.

Equations (2/3) could be altered for a re-parameterised Auto-regressive Distributed Lag Model (ARDL) error correction model for this paper with all independent variables in natural logarithm;

$$\Delta RSP_t = \theta_i[\Delta RSP_{t-1} - \phi_i'(lnGDP_t + lnEMP_t + lnEXC_t + lnREM_t)] + \sum_{j=1}^{p-1} \lambda_j \Delta RSP_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnGDP_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnEMP_{t-j} + \sum_{j=0}^{q-1} \varphi_{ij}' \Delta lnEXC_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnREM_{t-j} + \varepsilon_t \qquad (4)$$

Notes: $\theta_i =$ coefficient for speed of adjustment to equilibrium, which is expected to be less than 0. ϕ_i' = Coefficients of long-run relationships. $ECT = \theta_i[\Delta RSP_{t-1} - \phi_i'(lnGDP_t + lnEMP_t + lnEXC_t + lnREM_t)]$ represent the error correction term to be estimated. λ_j , φ_j' represent the short-run dynamic coefficients.

The nonlinear ARDL approach proposed by Shin *et al*. (2014) is employed to estimate the asymmetric relationship among the variables, recognising that movements in an independent variable may exert different effects depending on whether they are positive or negative. This method decomposes the independent variable into partial sums of positive and negative changes, as suggested by Qamruzzaman and Jianguo (2018), thereby allowing for asymmetric adjustment dynamics. Unlike traditional cointegration techniques, which impose a symmetric and linear relationship, the nonlinear ARDL framework relaxes this restriction and captures potential nonlinear responses in both the short run and the long run.

$$\begin{cases} POS(EXC)_t = \sum_{L=1}^{t} lnEXC_L^+ = \sum_{L=1}^{T} MAX(\Delta lnEXC_L, 0) \\ NEG(EXC)_t = \sum_{L=1}^{t} lnEXC_k^- = \sum_{L=1}^{T} MIN(\Delta lnEXC_L, 0) \end{cases} \qquad (5)$$

Equation (3) is rewritten in nonlinear form by incorporating a series of positive and negative changes, as follows:

$$\Delta RSP_t = \theta_i[\Delta RSP_{t-1} - \phi_i'(lnGDP_t + lnEMP_t + lnPOS(L)_t + lnNEG(L)_t) + lnEXC_t] + \sum_{j=1}^{p-1} \lambda_j \Delta RSP_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnGDP_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnEMP_{t-j} +$$

$\sum_{j=0}^{q-1} \varphi_j' \Delta lnPOS(EXC)_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnNEG(EXC)_{t-j} + \sum_{j=0}^{q-1} \varphi_j' \Delta lnREM_{t-j} + \alpha_i + \varepsilon_t$ (6)

Notes: θ_i remain the coefficient for speed of adjustment to equilibrium, which is expected to be less than 0. ϕ_i' is Coefficients of long-run relationships. $\theta_i[\Delta RSM_{t-1} - \phi_i'(lnGDP_t + lnEMP_{it} + lnPOS(EXC)_{it} + lnNEG(EXC)_{it} + lnREM_{it}]$ represent the error correction term to be estimated. λ_{ij} , φ_{ij}' represent the short-run dynamic coefficients.

4 RESULTS AND DISCUSSION

4.1 Descriptive statistics, correlation and unit root tests

Table 2 presents the descriptive statistics and correlation structure of the variables employed in the study over 34 observations. The summary statistics in Panel A show that all variables are expressed in natural logarithms, which helps to stabilise variance and allow for elasticity-based interpretation. Agricultural productivity (LPAG) and industrial productivity (LPIN) record mean values of 11.567 and 13.091 respectively, indicating that industrial productivity is, on average, higher than agricultural productivity over the sample period. The relatively larger standard deviation of LPAG (1.6051) compared to LPIN (1.246) suggests that agricultural productivity exhibits greater variability, reflecting its vulnerability to structural constraints and external shocks. GDP (LGDP) displays a comparatively low standard deviation (0.829), indicating relative macroeconomic stability in aggregate output compared to sectoral productivity indicators. Employment in agriculture (LEAG) shows very low dispersion, implying slow structural adjustment in agricultural labour, while employment in industry (LEIN) exhibits moderate variability. The exchange rate (LEXC) records notable variation, consistent with Nigeria's history of exchange rate instability, whereas inward remittances (LREM) display substantial dispersion, reflecting fluctuations in external financial inflows.

Table 2

Descriptive Statistics and Correlation

Panel A: Summary Statistics

Variable	LPAG	LPIN	LGDP	LEAG	LEIN	LEXC	LREM
Obs	34	34	34	34	34	34	34
Mean	11.567	13.091	26.141	17.833	16.466	4.745	22.227
Std. dev.	1.6051	1.246	0.829	0.1102	0.4340	1.162	1.929
Min	7.9714	10.217	24.676	17.566	15.891	2.293	17.849
Max	13.698	14.780	27.228	17.967	17.261	7.299	23.914

Panel B Correlation Matrix

Variables	LPAG	LPIN	LGDP	LEAG	LEIN	LEXC	LREM
LPAG	1						
LPIN	0.992	1					
LGDP	0.876	0.878	1				
LEAG	0.987	0.983	0.822	1			
LEIN	0.936	0.926	0.846	0.884	1		
LEXC	0.937	0.930	0.667	0.946	0.900	1	
LREM	0.929	0.927	0.831	0.929	0.839	0.857	1

Source: Author's Computation using Stata 18

Panel B reports the correlation matrix, which reveals strong positive relationships among most variables. Agricultural productivity (LPAG) is highly correlated with industrial productivity (LPIN), employment in agriculture (LEAG), employment in industry (LEIN), exchange rate (LEXC), and remittances (LREM), suggesting close interdependence between productivity, labour utilisation, and macroeconomic conditions. The positive correlation between exchange rate and productivity measures implies that exchange rate movements are associated with changes in real sector performance, although correlation does not imply causation. Similarly, GDP (LGDP) is positively correlated with all real sector indicators, indicating that improvements in sectoral productivity and employment coincide with higher aggregate output. While the high correlation coefficients point to strong linkages within the economy, they also suggest the possibility of multicollinearity, justifying the use of dynamic estimation techniques such as ARDL and NARDL that are robust to such relationships. Overall, the correlation results support the theoretical expectation that exchange rate dynamics and external inflows are closely linked to real sector productivity in Nigeria.

Table 3 presents the Augmented Dickey–Fuller (ADF) unit root test results for the variables used in the study and shows a mixed order of integration. Agricultural productivity (LPAG), employment in agriculture (LEAG), and inward remittances (LREM) are stationary at level, as their test statistics exceed the relevant critical values at conventional significance levels, indicating that they are integrated of order zero, I(0). In contrast, industrial productivity (LPIN), gross domestic product (LGDP), employment in industry (LEIN), and the exchange rate (LEXC) are non-stationary at level but become stationary after first differencing, implying that they are integrated of order one, I(1). Importantly, none of the variables is integrated of order two, I(2), satisfying the key precondition for the application of the ARDL and NARDL bounds testing approach. The presence of both I(0) and I(1) variables confirms the suitability of the chosen estimation techniques for examining the dynamic and asymmetric effects of exchange rate fluctuations on real sector productivity in Nigeria.

Table 3

Augmented Dickey-Fuller (ADF) Unit Root Test

Variables	Level (t-statistics)	1st difference (t-statistics)	Remarks
LPAG	-2.653*	-3.476***	I(0)
LPIN	-1.993	-4.049 ***	I(1)
LGDP	-2.107	-2.924***	I(1)
LEAG	-3.296**	-2.486	I(0)
LEIN	0.392	-3.474**	I(1)
LEXC	-0.086	-3.529**	I(1)
LREM	-2.660*	-6.644***	I(0)
Critical Values	10%	5%	1%
Level	-2.622	-2.980	-3.702
Ist Difference	-2.623	-2.983	-3.709

Note: * indicates stationery at 10 %, ** means stationery at 5%, and *** means stationery at 1%. Unit root test was based on Augmented Dickey-Fuller (ADF), using Stata 18

4.2 ARDL cointegration bound tests result

Table 4 reports the results of the ARDL bounds test for cointegration for the agricultural and industrial sector models. For Model A (Agriculture), the computed F-statistic of 4.099 exceeds the upper bound critical values at both the 10 percent and 5 percent significance levels, indicating rejection of the null hypothesis of no long-run relationship among the variables in the agricultural productivity model. Similarly, for Model B (Industry), the F-statistic of 8.209 is well above the upper bound critical values at all conventional levels, including the 1 percent level, providing strong evidence of cointegration in the industrial productivity model. These results confirm the existence of a stable long-run equilibrium relationship between exchange rate fluctuations and sectoral productivity in both agriculture and industry.

Table 4

Cointegration Bound Tests Result (ARDL)

F-statistic (A)	4.099	EC_{M-1}	-0.748***	(0.207)
F-statistic (B)	8.209	EC_{M-1}	-1.217***	(0.191)
Significant level		10%	5%	1%
F-Bounds Test	Lower bound	2.45	2.86	3.74
	Upper bound	3.52	4.01	5.06

Note: the number in parentheses represents t-statistics, *** signifies a 1% level of significance, F-statistics is determined with restricted constant and no trend; A-Linear ARDL Model for Agriculture and B-Linear ARDL Model for Industry

The error correction terms (ECM−1) for both models are negative and statistically significant at the 1 percent level, further validating the presence of long-run adjustment. Specifically, the ECM coefficient of −0.748 for the agricultural model implies that approximately 74.8 percent of short-run deviations from long-run equilibrium are corrected within one period, while the coefficient of −1.217 for the industrial model suggests an even faster adjustment process, with more than full correction occurring within the same period. This indicates a strong and rapid convergence toward long-run equilibrium, particularly in the industrial sector, and underscores the responsiveness of sectoral productivity to exchange rate dynamics in Nigeria.

4.3 ARDL long run and short run results

The long-run estimates in Table 5 reveal that exchange rate movements exert a positive and statistically significant impact on both agricultural and industrial productivity in Nigeria. Specifically, the coefficient of the exchange rate (LEXC) is 0.663 for agriculture and 0.923 for industry, both significant at the 1 percent level, indicating that exchange rate depreciation is associated with higher long-run sectoral productivity. This suggests that, over time, exchange rate adjustments may enhance competitiveness and encourage output expansion in both sectors, with the effect being stronger in the industrial sector. The long-run significance implies that firms and producers are able to gradually adjust to exchange rate changes through input substitution, export expansion, and improved resource allocation. These findings support the notion that exchange rate movements can contribute positively to real sector performance in the long run when adjustment mechanisms are allowed to operate fully.

Table 5

Long Run and Short Run Estimation Results for ARDL

VARIABLES	Agriculture	Industry
Long Run		
LGDP	0.618*** (0.0710)	1.053*** (0.0729)
EMP	3.555* (1.763)	-1.212*** (0.171)
LEXC	0.663*** (0.126)	0.923*** (0.0529)
LREM	0.00254 (0.0405)	-0.0214 (0.0242)
Short Run		
ECM	-0.748*** (0.207)	-1.217*** (0.191)
LD.LPAG	0.206 (0.187)	0.579*** (0.141)
D.LGDP	0.0273 (0.221)	-0.176 (0.244)
LD.LGDP	0.119 (0.0742)	-0.209*** (0.0677)
D.LEMP	0.393 (2.355)	0.358 (0.720)
LD.LEMP	-1.769 (2.562)	2.312** (0.859)
D.LEXC	-0.0468 (0.252)	0.0271 (0.252)
D.LREM	-0.00491 (0.0361)	-0.0245 (0.0355)
Constant	-53.22 (32.64)	1.765 (1.680)
Observations	32	32
R-squared	0.776	0.853
Serial Correlation	5.141/0.2234	1.227/0.2680
Heteroscedasticity Test	26.20/0.1000	0.00/0.9685

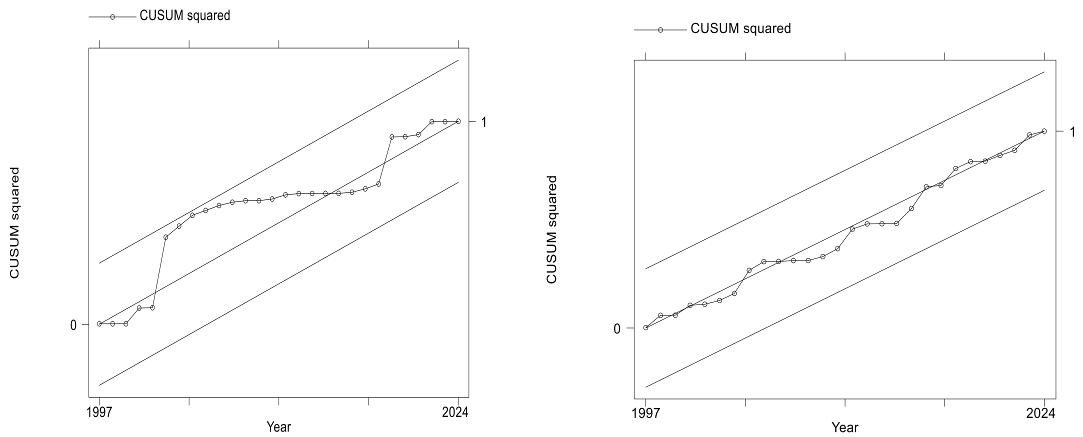
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In the short run, however, exchange rate effects appear to be weak and statistically insignificant across both sectors. The short-run coefficients of the first difference of the exchange rate (D.LEXC) are negative but insignificant for agriculture and positive but insignificant for industry, indicating that exchange rate changes do not exert an immediate influence on sectoral productivity. This short-run insignificance reflects adjustment rigidities, such as dependence on imported inputs, contractual obligations, and planning delays, which prevent producers from responding instantly to exchange rate shocks. The significant and negative error correction terms further indicate rapid adjustment toward long-run equilibrium, implying that short-run deviations caused by exchange rate fluctuations are quickly corrected over time. Overall, the results highlight a long-run dominance of exchange rate effects on real sector productivity in Nigeria, while short-run impacts remain muted and transitory.

The diagnostic statistics indicate that the estimated ARDL models are statistically adequate and reliable. The R-squared values of 0.776 for the agricultural model and 0.853 for the industrial model suggest that approximately 77.6 percent and 85.3 percent of the variations in sectoral productivity are explained by the regressors, indicating strong explanatory power. The serial correlation test results, with p-values of 0.2234 for agriculture and 0.2680 for industry, fail to reject the null hypothesis of no autocorrelation, implying that the residuals are independently distributed. Similarly, the heteroscedasticity test results, with p-values of 0.1000 and 0.9685 respectively, indicate homoscedastic residuals and the absence of variance instability in both models. Furthermore, the stability of the CUSUM of squares confirms parameter stability over the sample period, suggesting that the estimated coefficients are structurally stable and that the models are suitable for inference and policy analysis.

Figure 1

CUSUM squared



4.4 NARDL cointegration bound tests result

Table 6 presents the NARDL bounds test results for cointegration in the agricultural and industrial sector models. For Model C (Agriculture), the computed F-statistic of 3.395 lies slightly above the upper bound critical value at the 10 percent significance level, indicating rejection of the null hypothesis of no long-run relationship at this level. Although the evidence of cointegration for agriculture is weaker compared to the linear ARDL case, it nonetheless suggests the existence of a long-run nonlinear relationship between exchange rate movements and agricultural productivity. The associated error correction term (ECM_{-1}) is negative and statistically significant at the 1 percent level (−0.698), confirming long-run convergence and implying that about 69.8 percent of short-run deviations from equilibrium are corrected within one period.

For Model D (Industry), the F-statistic of 7.023 exceeds the upper bound critical values at all conventional significance levels, including the 1 percent level, providing strong evidence of cointegration in the nonlinear industrial model. The ECM_{-1} coefficient of −1.292, which is also significant at the 1 percent level, indicates a very rapid adjustment process, with more than full correction of disequilibrium within a single period. Overall, the results demonstrate that allowing for asymmetry in exchange rate movements strengthens the evidence of long-run relationships—particularly in the industrial sector—thereby justifying the use of the NARDL framework to capture nonlinear adjustment dynamics between exchange rate fluctuations and real sector productivity in Nigeria.

Table 6

Cointegration Bound Tests Result (NARDL)

F-statistic (C)	3.395	EC_{M-1}	-0.698***	(0.222)
F-statistic (D)	7.023	EC_{M-1}	-1.292***	(0.203)
Significant level		10%	5%	1%
F-Bounds Test	Lower bound	2.26	2.62	3.41
	Upper bound	3.35	3.79	4.68

Note: the number in parentheses represents t-statistics, *** signifies a 1% level of significance, F-statistics is determined with restricted constant and no trend; C-Nonlinear ARDL Model for Agriculture and D-Nonlinear ARDL Model for Industry

4.5 NARDL long run and short run results

The long-run NARDL estimates in Table 7 reveal clear asymmetric effects of exchange rate movements on real sector productivity in Nigeria. For the agricultural sector, the coefficient of positive exchange rate changes (LEXC_pos_cum) is positive and statistically significant, indicating that exchange rate depreciation enhances agricultural productivity in the long run. However, the coefficient of negative exchange rate changes (LEXC_neg_cum) is negative but statistically insignificant, suggesting that exchange rate appreciation does not exert a meaningful long-run influence on agricultural productivity. This implies a one-sided asymmetry in agriculture, where depreciation yields long-run productivity gains while appreciation effects are muted. In contrast, the industrial sector exhibits stronger and more pronounced asymmetry: both positive and negative exchange rate changes are statistically significant, but with differing magnitudes. Exchange rate depreciation positively and significantly affects industrial productivity in the long run, while exchange rate appreciation also shows a significant effect, indicating that industrial output responds more sensitively to exchange rate movements in either direction. These results suggest that industrial productivity is more exchange-rate-dependent than agricultural productivity in the long run.

In the short run, exchange rate effects are weak and statistically insignificant across both sectors. Neither the short-run coefficients of positive (D.LEXC_pos_cum) nor negative (D.LEXC_neg_cum) exchange rate changes are significant, indicating that immediate adjustments in productivity following exchange rate shocks are limited. This reflects short-run rigidities such as dependence on imported inputs, contractual arrangements, and adjustment costs that prevent firms from responding instantaneously to exchange rate movements. However, the error correction terms are negative and highly significant for both sectors, confirming rapid adjustment toward long-run equilibrium after short-run disturbances. Overall, the NARDL results highlight that exchange rate effects on real sector productivity in Nigeria are predominantly long-run and asymmetric, with depreciation-driven gains materialising over time, while short-run impacts remain transitory and economically insignificant.

The diagnostic statistics for the NARDL models indicate a good overall model fit and reliability. The R-squared values of 0.785 for the agricultural model and 0.867 for the industrial model suggest that about 78.5 percent and 86.7 percent of the variations in sectoral productivity are explained by the included regressors, reflecting strong explanatory power. The serial correlation test results, with p-values of 0.1019 for agriculture and 0.3541 for industry, fail to reject the null hypothesis of no autocorrelation, indicating that the residuals are free from serial dependence. Similarly, the heteroscedasticity test results, with p-values of 0.1000 and 0.6331 respectively, confirm homoscedastic residuals and the absence of variance instability. In addition, the stability of the CUSUM of squares test confirms parameter stability over the sample period, implying that the estimated coefficients are structurally stable and that the NARDL models are suitable for robust inference and policy analysis.

Table 7

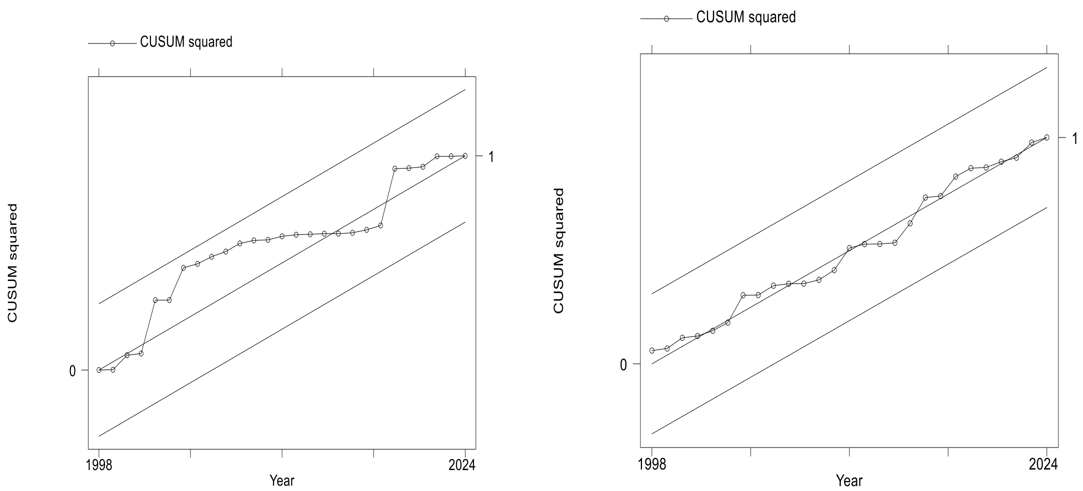
Long Run and Short Run Estimation Results for NARDL

VARIABLES	Agriculture	Industry
Long Run		
LGDP	0.537*** (0.134)	1.059*** (0.0693)
LEMP	3.781* (1.945)	-1.084*** (0.186)
LEXC_pos_cum	0.660*** (0.141)	0.888*** (0.0576)
LEXC_neg_cum	-0.966 (2.098)	1.960** (0.897)
LREM	-0.0339 (0.0692)	-0.00193 (0.0330)
Short Run		
ECM	-0.698*** (0.222)	-1.292*** (0.203)
LD.LPAG	0.163 (0.200)	0.629*** (0.148)
D.LGDP	0.0934 (0.242)	-0.265 (0.256)
LD.LGDP	0.145 (0.0838)	-0.240*** (0.0721)
D.LEMP	0.394 (2.444)	0.505 (0.733)
LD.LEMP	-2.209 (2.716)	2.301** (0.864)
D.LEXC_pos_cum	-0.0164 (0.264)	-0.00755 (0.255)
D.LEXC_neg_cum	-0.0399 (1.827)	-1.345 (1.684)
D.LREM	0.00760 (0.0406)	-0.0447 (0.0412)
Constant	-49.43 (33.88)	1.312 (3.093)
Observations	32	32
R-squared	0.785	0.867
Serial Correlation	9.649/0.1019	0.859/0.3541
Heteroscedasticity Test	29.31/0.1000	0.23/0.6331

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Figure 2

CUSUM squared



4.6 Discussion of findings

The linear ARDL results of this study show that exchange rate movements exert a positive and significant long-run effect on both agricultural and industrial productivity in Nigeria, while short-run effects are largely insignificant. This finding aligns partly with Nigerian evidence that suggests exchange rate adjustments can support real sector performance over time by improving competitiveness and encouraging output expansion once adjustment costs are absorbed. For instance, Gimba *et al*. (2025) show that exports enhance growth when moderated by exchange rate volatility, while Jacob and Rosemary (2022) and Miftahu and Shuyur (2023) find that exchange rate movements can stimulate growth, particularly in the short run. However, the insignificance of short-run exchange rate effects in the ARDL results contrasts with some growth-based studies, suggesting that productivity responses—especially in manufacturing and agriculture—are slower and constrained by structural rigidities such as import dependence and adjustment costs. This also resonates with Malec *et al*. (2024) and Hordofa (2023), who argue that depreciation can constrain production in the short run by raising the cost of imported intermediate goods.

When compared with the ARDL results, the NARDL estimates provide deeper insights by uncovering asymmetric long-run effects of exchange rate movements, particularly in the industrial sector. While exchange rate depreciation consistently enhances long-run productivity, exchange rate appreciation exhibits differentiated effects across sectors—insignificant in agriculture but significant in industry. This asymmetric behaviour supports the findings of Uche and Nwamiri (2021), who document nonlinear pass-through from exchange rates to productivity in Nigeria, as well as Iqbal *et al*. (2023) for India, where undervaluation promotes growth while overvaluation is harmful. The NARDL results also help reconcile the mixed evidence in the Nigerian literature: studies such as Ayobami (2019) that find positive effects of exchange rate volatility on manufacturing performance may be capturing depreciation-driven gains, whereas Adebanjo *et al*. (2019) and Ehikioya (2019) highlight the adverse effects of volatility and depreciation when adjustment asymmetries and shocks dominate. By explicitly separating positive and negative exchange rate changes, the NARDL framework reveals that linear models may mask important distributional and directional effects.

Overall, the comparison of ARDL and NARDL results underscores the importance of nonlinearity and asymmetry in understanding the exchange rate–real sector productivity nexus in Nigeria. While the ARDL model confirms the existence of stable long-run relationships consistent with much of the traditional literature (Ikechi & Nwadiubu, 2020; Han, 2020), the NARDL results demonstrate that the magnitude and direction of exchange rate effects depend on whether the naira is depreciating or appreciating. This is consistent with recent international evidence that exchange rate shocks are regime-dependent and time-varying, as shown by Odoom *et al*. (2025) and Oppong *et al*. (2026) for Ghana, and by the meta-analysis of Ridhwan *et al*. (2024) for developing countries. Consequently, the findings of this study strengthen the argument that policy conclusions based solely on linear exchange rate models may be incomplete, and that asymmetric frameworks such as NARDL are better suited for capturing the true productivity implications of exchange rate fluctuations in Nigeria's real sector.

The empirical results of this study remain consistent with the core propositions of the Investment Uncertainty Theory advanced by Bernanke (1983) and Dixit and Pindyck (1994). The insignificant short-run effects of exchange rate movements on agricultural and industrial productivity obtained from both the ARDL and NARDL estimations reflect firms' cautious behaviour under uncertainty, as predicted by the theory. Faced with volatile exchange rate movements, producers are likely to postpone or scale down irreversible investments in machinery, technology, and capacity expansion, resulting in muted short-run productivity responses (Ehikioya, 2019; Uche & Nwamiri, 2021). However, the significant long-run effects of exchange rate movements, particularly the positive impact of depreciation and the asymmetric responses revealed by the NARDL model, suggest that once uncertainty diminishes and firms gradually adjust their production structures, productivity gains can emerge. This long-run adjustment process is consistent with the real options framework, which posits that uncertainty delays—but does not permanently eliminate—productive investment. The findings therefore support the Investment Uncertainty Theory by showing that exchange rate fluctuations primarily influence real sector productivity in Nigeria through delayed adjustment and asymmetric long-run responses, in line with evidence reported by Ayobami (2019), Ezenwaka *et al*. (2025), and Gimba *et al*. (2025).

5 CONCLUSION

This study investigated the effects of exchange rate fluctuations on real sector productivity in Nigeria, focusing specifically on agricultural and industrial output over the period 1991–2024, using ARDL and NARDL estimation techniques to capture both dynamic and asymmetric relationships. The results confirm the existence of stable long-run relationships between exchange rate movements and sectoral productivity, while short-run effects remain largely insignificant. Exchange rate movements were found to exert a positive and significant influence on agricultural and industrial productivity in the long run, with the NARDL estimates further revealing asymmetric effects—particularly in the industrial sector—indicating that productivity responses differ between exchange rate depreciation and appreciation. The weak short-run effects suggest that uncertainty, adjustment costs, and structural rigidities limit immediate productivity responses, whereas long-run significance reflects gradual adaptation through investment decisions, input substitution, and market adjustments. Overall, the findings highlight that exchange rate fluctuations influence Nigeria’s real sector productivity primarily through long-run and asymmetric channels rather than short-run adjustments.

In light of these findings, the study recommends that policymakers emphasise exchange rate stability and consistency as a core macroeconomic objective to reduce uncertainty and encourage productivity-enhancing investment in agriculture and industry. Exchange rate policy should be complemented with measures that strengthen domestic production structures, such as promoting local sourcing of inputs, supporting agro-processing and manufacturing value chains, and improving access to affordable long-term finance. Furthermore, given the asymmetric effects identified, policymakers should recognise that depreciation and appreciation have differing implications across sectors; thus, exchange rate management should be aligned with targeted industrial and agricultural policies to ensure that exchange rate adjustments translate into sustainable long-run productivity gains rather than short-term disruptions.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

How to cite this article (APA)

Uwaeme, G. C., Diyoke, K. O., & Azu, N. P. (2026). ANOTHER LOOK AT THE EXCHANGE RATE FLUCTUATIONS ON REAL SECTOR PRODUCTIVITY IN NIGERIA. Veredas Do Direito, 23(4), e234939. https://doi.org/10.18623/rvd.v23.n4.4939