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Exchange Rate Depreciation and the Nigeria's Agricultural and Industrial Sectors

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study examines the effect of exchange rate depreciation on the agricultural and industrial sectors of the Nigerian economy using annual data from 1981 to 2021 in an autoregressive distributed lag (ARDL) model. The findings show that the effect of exchange rate depreciation on industrial and agricultural output was fairly similar. Exchange rate depreciation, inflation, interest rate, and government expenditure have negative effects on industrial output in the short run and positive effects in the long run. Similarly, past agricultural output, exchange rate depreciation, and government expenditure have negative effects on agricultural output in the short run and a positive effect in the long run. Inflation also has a long-term positive effect on agricultural output. Government expenditure had the most substantial long-run effect on industrial and agricultural

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output. The study shows the need to manage high exchange rate volatility to facilitate realistic forecasts and sound production decisions in the agricultural and industrial sectors. The findings of this study underscore the importance of considering both short-run dynamics and long-run adjustments in understanding the effects of exchange rate depreciation and other economic variables on the industrial and agricultural sectors.

Keywords: Exchange rate depreciation; output; short-run effects; long-run effects; Autoregressive distributed lag model; Nigeria.

1. INTRODUCTION

The exchange rate is one of the intermediate policy variables through which the monetary authority influences economic activities, it is one of the channels through which monetary policy is transmitted to the macro economy with the aim of promoting internal and external stability such as price stability, sustainable economic growth, healthy balance of payment, and full employment. Hence, changes in exchange rates affect other macroeconomic variables, it can lead to changes in the domestic prices of goods and services, affect the levels of spending of individuals, firms, and even the public sector, affect the balance of payment stance of the country, and ultimately affect the growth trajectory of the economy [1-3].

Numerous exchange rate regimes have been practiced globally ranging from the extreme cases of fixed exchange rate systems such as the currency boards and unions to a freely floating regime. In most cases, countries tend to practice a mixture of regimes such as adjustable peg, crawling peg, target zone/crawling bands, and managed float exchange rate systems, depending on what suits their peculiar economic conditions. However, irrespective of the system adopted, changes in the exchange rate affect macroeconomic fundamentals such as import, export, current account balances, general price level, interest rate, agricultural output, industrial output, etc [4].

In Nigeria, the exchange rate arrangements have undergone significant changes over the years. From the fixed regime in the 1960s to a pegged arrangement between the 1970s and the mid-1980s and finally to the various types of the floating regime since 1986 following the adoption of the Structural Adjustment Programme (SAP). These changes are not however peculiar to the Naira alone as the US dollar for instance was fixed in gold terms until 1971 when it was de-linked and has since been floated [5].

Like every other macroeconomic policy, exchange rate policies are made to produce desirable macroeconomic outcomes in all sectors of the economy. The role of the agricultural and industrial sectors in any economy cannot be over-emphasized. Various theories have explained this importance amongst which is the Rostow stages of growth theory which emphasizes investment and development of the agricultural and some core industrial sectors as the precondition for takeoff to economic growth and development [6]. For a developing country like Nigeria with a highly young population and a high number of people engaged in agriculture, understanding the effect of external shocks through exchange rate movement on the agricultural and industrial sectors is key to actualizing economic growth and development in the country given the country's over-dependence on oil exports as a major source of income.

Over the years, the Nigerian Naira in relation to the currencies of other countries like the US dollar has steadily depreciated. This has continued despite the various interventions by the Central Bank in the foreign exchange market. Theoretically, currency depreciation is expected to lead to an increase in the demand for locally produced goods and a reduction in imports in line with the Marshall-Lerner conditions (Jhingan, 2004). Therefore, from the underpinnings of how the exchange rate affects external trade, an increase in domestic output can be a response to currency depreciation.

While the effect of exchange rate movement on aggregate economic output is a topic of interest, the effect of exchange rate on sectoral output is also important to understand the effect of exchange rate changes on the economy on a more disaggregated basis. This research is therefore conducted primarily to examine the impact of exchange depreciation on the industrial and agricultural output in the short and long runs using data from 1981 to 2020. Some of the previous works in this area were on the impact of exchange rate on the manufacturing sector [7], exchange rate dynamism on current account balances [8] impact of exchange rate on economic growth [9], the impact of exchange rate on general price level [10,11].

2. LITERATURE REVIEW

2.1 Theoretical Framework

Theoretically, the link between exchange rate and economic activities is expressed in the Keynesian Macroeconomic Theory where net export which is a component of aggregate demand is linked to the exchange rate [12]. From the components of aggregate expenditure, national income is equal to household spending on consumption, business spending on investments, government spending, and the net of foreigners spending on domestic goods and domestic spending on foreign goods. A change in any of the four variables all things being equal will lead to a change in the national income. The national income identity is expressed as follows;

$$Y = C + I + G + X\text{-}M \quad (1)$$

Where Y is the national income, C is household consumption, I is investment, G is government expenditure and X-M is the exports minus imports. Now, taking out the net exports and holding other variables constant, a change in the real exchange rate will lead to a change in a country's net exports. The real exchange rate which is defined as the nominal exchange rate multiplied by the relative price levels shows the rate at which foreign goods can be exchanged for domestic goods. It is given as:

$$\mathcal{E} = e \times p/p^* \quad (2)$$

Where p is the price of goods in the foreign country, p* is the price of goods in the domestic country and e is the nominal exchange rate. The real exchange rate is therefore determined by the nominal exchange rate, domestic prices, and foreign prices as depicted in the equation. The higher the nominal exchange rate relative prices held constant, the higher the real exchange rate, hence the real exchange rate is positively related to the nominal exchange rate. Thus, when the nominal exchange rate depreciates with relative prices held constant, the real exchange rate will depreciate, domestic goods will become cheaper, foreign goods will become more expensive, demand will shift to domestic goods and the country's net exports will improve. This negative relationship between the real exchange rate and net export is depicted in the figure.

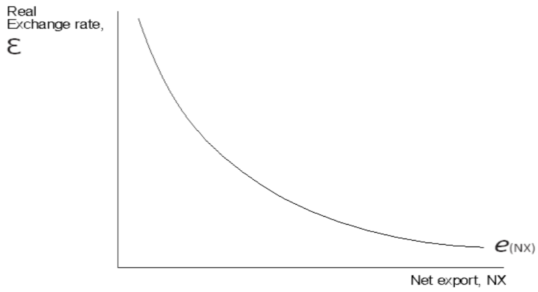


Fig. 1. The relationship between real exchange rate and net export

Based on the aggregate expenditure theory of the Keynesian model, a similar theory that explains the relationship between exchange rate and economic output is known as the Absorption Approach to exchange rate determination. According to this theory, a country's deficit in its balance of payments means that people are 'absorbing' more than they produce, that is, national income is less than domestic expenditure on consumption and investment. Using the national income identity absorption is simple:

$$Y = \underbrace{C + I + G}_{\text{Absorption}} + X\text{-}M \quad (3)$$

If absorption; the sum of (C + I + G) is represented by A and the balance of payments (X – M) is represented by B then, (3) above becomes:

$$Y = A + B \text{ or } B = Y - A \quad (4)$$

Equation (4) simply means that the national current account of a country is the difference between national income (Y) and absorption (A). Thus, the balance of payment can be improved by either increasing domestic income or reducing the absorption. To achieve this purpose, the absorption approach advocates a currency devaluation which leads to increases in exports, reduces imports, and increases the national income given that the economy is operating below the full employment level i.e., there are unemployed resources. This increase in income induced by devaluation and export will further increase income through the multiplier effect. If the economy is however at full employment level, this devaluation will lead to an increase in prices instead of output growth.

2.2 Empirical Literature

Empirical studies investigating the impact of exchange rate dynamics on the agricultural and industrial sectors of Nigeria have contributed valuable insights to the understanding of macroeconomic relationships within the country's economy. While limited research specifically explores this nexus, existing studies shed light on various dimensions of how exchange rate movements influence industrial production, agricultural exports, and broader economic performance.

Akinlo and Lawal [13] utilized a vector error correction model (VECM) to explore the relationship between exchange rate depreciation and industrial production in Nigeria. Their findings indicated a long-run association between exchange rate depreciation and industrial output. Interestingly, they observed that while money supply shocks significantly affected industrial production, exchange rate depreciation itself did not directly impact the extent of industrial output.

In contrast, Ogunmuyiwa and Adelowokan [14] adopted time series analysis methods, including the Box Jenkins Ordinary Least Squares (OLS) approach and the Chow breakpoint test, to examine the influence of exchange rate on industrial output over a similar period. Surprisingly, their study concluded that no long-run relationship existed between exchange rate movements and industrial production in Nigeria. Waziri et al. [15] focused on the export of agricultural raw materials and economic growth, employing the Autoregressive Distributed Lag Model (ARDL). Their research highlighted a positive impact of the exchange rate on the export of agricultural raw materials, suggesting a potential link between exchange rate dynamics and agricultural sector performance.

Iwegbu and Nwaogwugwu [16] investigated the effects of exchange rate shocks on key sectors of Nigeria's economy across different regulatory regimes. Through Structural Vector Regression (SVAR) and related methods, they found that agricultural and industrial outputs did not demonstrate significant responsiveness to exchange rate shocks in the short and long runs under regulated conditions. However, in a guided deregulated regime, industrial output was more negatively impacted by exchange rate shocks than agricultural output in the long run.

Ekundayo et al. [17] took a broader perspective by examining the macroeconomic implications of exchange rate depreciation using the Autoregressive Distributed Lag (ARDL) Bounds testing Cointegration approach. Their study suggested that while Naira depreciation did not notably affect output per capita, it did have positive effects on trade, prices, and interest rates.

Effiong and Okon [18] focused on monetary policy tools and exchange rate stability's role in stimulating output growth. They found that a stable exchange rate could indeed promote economic growth. Additionally, Okon et al. [19] explored the relationship between exchange rate and inflation, highlighting a negative interaction between exchange rate movements and inflation in terms of economic growth.

In a more recent study, Effiong, Arinze, and Okon [20] delved into exchange rate movements' effects on fiscal and monetary policy interactions, aiming to understand the connection between exchange rate dynamics and the real economy [21-23]. Their findings underscored the critical role of precise policy formulation and implementation in mitigating the potentially adverse impacts of exchange rate fluctuations on the real economy.

These diverse empirical studies collectively emphasize the multifaceted nature of exchange rate dynamics and their implications for key sectors of Nigeria's economy [24,25]. While findings vary across studies, they collectively contribute valuable insights for policymakers and researchers seeking to navigate the complex interplay between exchange rates, industrial production, agricultural performance, and broader economic stability and growth in Nigeria.

3. METHODOLOGY

The objective of this study is achieved by using the econometric method to analyze data. The data used in this paper are secondary in nature ranging from 1981 to 2021. They were obtained from the statistical bulletin of the Central Bank of Nigeria (CBN 2021 bulletins).

3.1 Model Specification

This article is based on the open economy version of the Keynesian theory of aggregate demand where an increase in the nominal exchange rate leads to an increase in the real exchange which further leads to an increase in net export and ultimately domestic output [26,27].

Previous studies were also taken into consideration in the choice of variables used in the model of this study, particularly the work of Ekundayo et al. [17] with modifications. The model of this study is expressed as follows;

IND= f (EXCH, INF, GOV, RIR) (5)

AGR= f (EXCH, INF, GOV, RIR) (6)

Where;

IND_t = Industrial output (N' Billions)
AGR_t = Agricultural output (N' Billions)
$EXCH_t$ = CBN official exchange rate of the naira to dollar
INF_t = Inflation rate (%)
GOV_t = government capital expenditure (N' Billions)
RIR_t = Real Interest Rate (%)

Mathematically stated as:

$$LIND_t = \beta_0 + \beta_1 EXCH_t + \beta_2 INF_t + \beta_3 LGOV_t + \beta_4 RIR_t + \mu_t \quad (7)$$

$$LAGR_t = \beta_0 + \beta_1 EXCH_t + \beta_2 INF_t + \beta_3 LGOV_t + \beta_4 RIR_t + \mu_t \quad (8)$$

Where;

$LIND_t$ = The log of industrial output
$LAGR_t$ = The log of agricultural output
$EXCH_t$ = CBN official exchange rate of the naira to dollar
INF_t = Inflation Rate (%)
$LGOV_t$ = The log of government capital expenditure
RIR_t = Real Interest Rate (%)
$\beta_1, \beta_2, \beta_3, \beta_4$ and are the model coefficients
β_0 = intercept term
μ_t = disturbance term

3.2 Analytical Technique

The advanced econometric technique of the Autoregressive Distributed Lag model (ARDL) is employed to examine the long-run and short-run effect of exchange rate depreciation on agricultural and industrial output. In the ARDL model, the dependent variable is expressed as a function of the lag value of the dependent variable and the current and lag values of the explanatory variables. The ARDL models for this study are expressed as follows;

Model I

$$\mathrm{L}IND_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \mathrm{LIND}_{t-i} + \beta_2 \mathrm{EXCH}_t + \beta_3 \sum_{k=i}^{q} \mathrm{EXCH}_{t-i} + \beta_4 \mathrm{INF}_t + \beta_5 \sum_{k=i}^{q} \mathrm{INF}_{t-i} + \beta_6 \mathrm{LGOV}_t + \beta_7 \sum_{k=i}^{q} \mathrm{LGOV}_{t-i} + \beta_8 \mathrm{RIR}_t + \beta \quad \sum_{k=i}^{q} \mathrm{RIR}_{t-i} + \mu \quad (9)$$

Model II

$$\mathrm{L}AGR_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \mathrm{LIND}_{t-i} + \beta_2 \mathrm{EXCH}_t + \beta_3 \sum_{k=i}^{q} \mathrm{EXCH}_{t-i} + \beta_4 \mathrm{INF}_t + \beta_5 \sum_{k=i}^{q} \mathrm{INF}_{t-i} + \beta_6 \mathrm{LGOV}_t + \beta_7 \sum_{k=i}^{q} \mathrm{LGOV}_{t-i} + \beta_8 \mathrm{RIR}_t + \beta_9 \sum_{k=i}^{q} \mathrm{RIR}_{t-i} + \mu \quad (10)$$

3.3 Analytical Procedures

The process of estimating the models is as follows;

Test for Stationarity: The test for stationarity is an essential procedure that must be undertaken before estimating a regression model to avoid the problem of spurious regression and also give insight into the appropriate regression technique to adopt (Gujarati, 2009). The Augmented Dickey-Fuller (ADF) test will be used to conduct this test since it adjusts for serial correlation. The general form is;

$$\Delta Y_t = \alpha + \sum_{k=i}^{p} \delta Y_{t-i} + \sum_{k=i}^{p} \phi \Delta Y_{t-i} + ut \quad (11)$$

Where Yt stands for the time series data of interest, Δ is the first difference operator, "t" is time, and "t-i" stands for time lag. Greek letters (α, δ, ϕ) are parameters to be estimated and u_t is error term.

ARDL Bond Test for Co-integration: Co-integration test is used to show whether the linear combination of non-stationary time series is stationary. That is, although the time series is integrated of say order one I (1), its linear combination can be I (0). Economically speaking, two variables will be co-integrated if they have a long-term, or equilibrium relationship between them (Gujarati, 2009).

To carry out this test, the ARDL Bounds test is employed. The benefit of this test lies in its ability to handle time series integrated of I (0) and I (1) without differencing. It is conducted under the null hypothesis of no co-integration. The F-statistics value will be compared against two critical value bounds (upper and lower bound). If the computed F-statistic falls below the lower bound at 0.05 significant level we would accept the null hypothesis and conclude that there is no co-integration. If on the other hand, the F-statistic exceeds the upper bound at 0.05 significant level, we conclude that we have co-integration. Finally, the test would be inconclusive if the F-statistic falls between the lower and upper bounds.

The equation of the bond test procedure is specified as follows;

Model I

$$\Delta\text{LIND}_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \text{LIND}_{t-i} + \beta_2 \sum_{k=i}^{p} \text{EXCH}_{t-i} + \beta_3 \sum_{k=i}^{q} \text{INFt}_{t-i} + \beta_4 \sum_{k=i}^{q} \text{LGOV}_{t-i} + \beta_5 \sum_{k=i}^{q} \text{RIR}_{t-i} + \beta_6 \sum_{k=i}^{p} \Delta\text{EXCH}_{t-i} + \beta_7 \sum_{k=i}^{q} \Delta\text{INFt}_{t-i} + \beta_8 \sum_{k=i}^{q} \Delta\text{LGOV}_{t-i} + \beta_9 \sum_{k=i}^{q} \Delta\text{RIR}_{t-i} + U_t \quad (12)$$

Model II

$$\Delta\text{LAGR}_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \text{LAGR}_{t-i} + \beta_2 \sum_{k=i}^{p} \text{EXCH}_{t-i} + \beta_3 \sum_{k=i}^{q} \text{INFt}_{t-i} + \beta_4 \sum_{k=i}^{q} \text{LGOV}_{t-i} + \beta_5 \sum_{k=i}^{q} \text{RIR}_{t-i} + \beta_6 \sum_{k=i}^{p} \Delta\text{EXCH}_{t-i} + \beta_7 \sum_{k=i}^{q} \Delta\text{INFt}_{t-i} + \beta_8 \sum_{k=i}^{q} \Delta\text{LGOV}_{t-i} + \beta_9 \sum_{k=i}^{q} \Delta\text{RIR}_{t-i} + U_t \quad (13)$$

If the variables are not co-integrated then there would be no basis for estimating the long-run equations. However, if the variables are co-integrated, equations 7 and 8 which are the long-run equations are estimated as well as the short run error correction model.

The Error Correction Model (ECM): In the presence of a long-run relationship between the dependent and independent variables, an Error Correction Model (ECM) is estimated to show the speed of adjustment to long run equilibrium. The model for this study is expressed as follows;

Model I

$$\Delta\text{LIND}_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \Delta\text{LIND}_{t-i} + \beta_3 \sum_{k=i}^{q} \Delta\text{EXCH}_{t-i} + \beta_4 \sum_{k=i}^{q} \Delta\text{INFt}_{t-i} + \beta_5 \sum_{k=i}^{q} \Delta\text{LGOV}_{t-i} + \beta_6 \sum_{k=i}^{q} \Delta\text{RIR}_{t-i} + \lambda\text{ECM}_{t-i} + \mu_t \quad (14)$$

Model II

$$\Delta\text{LAGR}_t = \beta_0 + \beta_1 \sum_{k=i}^{p} \Delta\text{LAGR}_{t-i} + \beta_2 \sum_{k=i}^{q} \Delta\text{EXCH}_{t-i} + \beta_3 \sum_{k=i}^{q} \Delta\text{INFt}_{t-i} + \beta_4 \sum_{k=i}^{q} \Delta\text{LGOV}_{t-i} + \beta_5 \sum_{k=i}^{q} \Delta\text{RIR}_{t-i} + \lambda\text{ECM}_{t-i} + \mu_t \quad (15)$$

It is expected that ECM_{t-i} should fall between 0 and -1. If ECM_{t-i} is statistically significant, it is an indication that any short-run deviation between the dependent and independent variables will converge to the long-run equilibrium.

3.4 Post Estimation Daignostics

Regression analysis is based on certain assumptions. These assumptions include that the error terms are normally distributed, the absence of serial correlation, and the absence of heteroscedasticity. Consequently, the normality test, serial correlation test, and heteroscedasticity test are carried out to check the fulfillment of regression assumptions. A model stability test is also conducted.

4. PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

In this section, our findings are presented and discussed. It is divided into four parts starting with the descriptive statistics, unit root and co-integration test followed by the short and long dynamics of the model, and the post-estimation tests.

4.1 Unit Root, and Cointegration Test

Unit Root Test: Table 1 shows the test for stationarity using both the Augmented Dickey-Fuller. The result shows that LAGR, LIND, EXCH, and LGOV are not stationary at level but at first difference while RIR and INF are stationary at levels.

Co-integration Test: The Bound test results for the two models are presented in Table 2. From the table, since the F-statistic value of 17.98 and 8.54 for models I and II respectively is more than the upper bound value of 3.49 at a 0.05 significant level, we conclude that our variables have a long-run relationship.

4.2 Long Run Analysis

Following the result of the bond test for cointegration which shows the existence of a long-run relationship, equations 7 and 8 are estimated. Table 3 shows the ARDL long-run coefficients of the models.

Model I

Model I shows that exchange rate depreciation has a positive impact on industrial output with a coefficient of 0.003894. The positive coefficient suggests that in the long run, a 1 %increase in exchange rate(naira depreciation) leads to a 0.003894% increase in industrial output. This could be due to improved export competitiveness, increased demand for domestic goods, or enhanced profitability for export-oriented industries as a result of exchange rate depreciation.

The model also shows that inflation and government capital expenditure positively impact industrial output in the long run with a coefficient of 0.011712 and 0.813006, respectively. This means that a 1% increase in inflation and capital expenditure leads to a 0.011712% and 0.813006% increase in industrial output, respectively. The positive coefficient of inflation indicates that higher inflation levels contribute positively to industrial output in the long run. This relationship may reflect increased consumer demand and nominal revenue growth for businesses during periods of inflation. Higher prices due to increase in demand usually serves as incentives for business to increase production to take advantage of higher returns.

The substantially positive coefficient (0.813006) of government capital expenditure which shows almost a parity effect underscores the significant role of public investment in fostering industrial output over time. Increased government spending on infrastructure and development projects can stimulate economic activity, boost demand for industrial goods, and enhance overall industrial productivity.

Surprisingly, the real interest rate was found not to have a significant effect on industrial output in the long run perhaps because expectations have been adjusted and the reality of the high cost of borrowing accepted. Investment decisions and economic behavior may have adjusted to

Table 1. Unit root test

Variable	**Augmented Dickey-Fuller Test**		
	Level	**1st Difference**	**Order of Integration**
LAGR	-2.05579	-3.991906	I (1)
P- Value	(0.263)	(0.0037)	
LIND	-0.62828	-4.745687	I (1)
	(0.8526)	(0.0004)	
EXCH	2.161587	-4.126391	I (1)
P- *Value*	(0.9999)	(0.0026)	
RIR	-7.35955		I (O)
P- *Value*	0		
LGOV	-1.0836	-6.356808	I (1)
P- *Value*	(0.7127)	0	
INF	-2.95847		I (O)
	0.0479		

Table 2. Co-integration Test

Model I

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	17.98208	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Model II

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	8.538630	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

accommodate prevailing interest rate conditions. This finding implies that the cost of borrowing is not the primary determinant of changes in industrial output in the long term.

Model II

Model II also shows that exchange rate depreciation, inflation, and government capital expenditure have a positive impact on agricultural output with coefficients of 0.001967, 0.010881, and 1.033396, respectively. This means that a % increase in exchange rate (exchange rate depreciation), inflation and government capital expenditure leads to a 0.001967%, 0.010881% and 1.033396% increase in agricultural output in the long run.

The positive effect of exchange rate depreciation on agricultural output may be attributed to improved competitiveness of agricultural exports or increased demand for domestic agricultural products in response to currency depreciation. Similar to its impact on industrial output, the positive coefficient of inflation indicates that higher inflation levels positively influence agricultural output over time because increased agricultural prices and revenues, stimulates production and investment in the agricultural sector.

Table 3. Long Run Coefficients

Model I

Levels Equation				
Dependent Variable: LIND				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
***EXCH	0.003894	0.000661	5.889603	0.0000
**INF	0.011712	0.005027	2.329917	0.0299
***LGOV	0.813006	0.062815	12.94282	0.0000
RIR	0.002662	0.008666	0.307206	0.7617
***C	1.350443	0.153535	8.795673	0.0000

Model II

Levels Equation				
Dependent Variable: LAGR				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
**EXCH	0.001967	0.000884	2.225153	0.0357
*INF	0.010881	0.005888	1.847886	0.0770
***LGOV	1.033396	0.093645	11.03519	0.0000
RIR	-0.004246	0.007684	-0.552576	0.5857
***C	1.056526	0.220174	4.798591	0.0001

** indicates 10% level of significance; ** indicates 5% level of significance; *** indicates 1% level of significance*

The significant positive coefficient (1.033396) of government capital expenditure on agricultural output which shows a parity relationship, also highlights the crucial role of public investment in driving agricultural sector growth in the long run. Government investments in agricultural infrastructure, research, and development can enhance productivity, expand markets, and improve overall performance of the agricultural sector.

Equations 12 and 13 which are the error correction models were estimated to show the speed of adjustments of the dependent variables to long equilibrium since there is a long-run relationship between the dependent and independent variables as shown in Table 4. The ECM values of -0.60 and -0.58 with a *p-value* of 0.00 for model I and II respectively means that any short-run deviation from the long-run equilibrium will adjust at 60 and 58 percent for model I and II respectively, per period. To calculate the exact speed of adjustment, we divide 1 by the ECM coefficient which gives the value of 1.64 and 1.72, respectively. Given that annual data was used, this means that it takes approximately one year, eight months in model I, and one year nine months in model II for the dependent variables to adjust back to long-run equilibrium after a deviation.

4.3 Short Run Analysis

Following the estimation of the long-run coefficients, the short-run error correction models (equations 12 and 13) are also estimated and presented in Table 4.

Model I

The coefficients of variables in equation 12 of the error correction model show that in the short run exchange depreciation at the current period and at lag 2 has a significant negative effect on industrial output with the coefficient of -0.001432 and -0.001765, respectively but a positive effect at lag 1. The negative coefficients suggest that a depreciation of the exchange rate in the short run has a dampening effect on industrial output. This could indicate increased production costs or reduced competitiveness of domestic industries due to currency devaluation. Most of the machinery used in the Nigerian industries is imported and an exchange rate deterioration will discourage production since more funds will be required to finish or continue production having used a lower exchange rate as a benchmark.

Inflation at lag 1 has a significant negative effect on industrial output with a coefficient of -0.00167. The negative coefficient of inflation at lag 1 implies that higher inflation levels in the previous period negatively impact current industrial output. This indicates that higher general prices, likely because of the pass-through effect of exchange rate depreciation increased production costs and also reduced consumer purchasing power, leading to a reduction in both supply and demand of industrial output.

Government expenditure has a significant positive effect on industrial output in the current period and a negative in the previous period (lag 1). The positive coefficient of government expenditure on current industrial output suggests that higher government spending stimulates industrial production in the short run. This is in line with the theoretical basis of this study where an increase in government is seen as the primary way of stimulating aggregate output. However, the negative coefficient at lag 1 indicates that the previous period's government expenditure has adverse effects on current industrial output, possibly due to fiscal policy adjustments, delays, or misappropriation of funds.

The real interest rate has a significant negative effect on industrial output in both current and previous periods with a coefficient of -0.005104, -0.004501, and -0.000974 for the current period, lag 1 and lag 2 respectively. The consistently negative coefficients of real interest rates highlight the adverse impact of higher interest rates on industrial output. This means that higher real interest rates discourage investment and borrowing, thereby constraining industrial growth. This is in line with postulations of Keynesian macroeconomic theory.

Model II

The coefficients of the variables in equation 13 show that the previous period's agricultural output at lag 2 has a significant negative effect on the current industrial sector output. A certain percentage of agricultural output usually serves as input for the following year's agricultural activities. Thus, low output in previous periods will have a dampening effect on current period output.

Exchange rate depreciation at lag 1 has a negative effect on agricultural output with a coefficient of -0.000993. The negative coefficient could be due to increased costs of imported inputs or reduced competitiveness of agricultural exports. Government expenditure at lag 2 has a negative effect on the output of the agricultural sector with a coefficient of -0.159115. The negative coefficient implies that government spending in the preceding period has a negative impact on current agricultural sector output. This could reflect inefficiencies or misallocation of government resources affecting agricultural productivity.

Inflation and real interest rates were automatically excluded during the estimation process with Eviews, likely because they did not contribute significantly to the explanatory power of the model and hence were automatically dropped from the estimation of equation 13 during the estimation process.

4.4 Post Estimation Tests

To be sure that our model result fulfills regression assumptions, we estimate the serial correlation test, model stability, and heteroscedasticity test all presented and discussed in this section.

Table 4. Error Correction Model

Model I

ECM Regression				
Dependent Variable: ∆(LIND)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
***∆(EXCH)	-0.001432	0.000289	-4.953108	0.0001
**∆(EXCH(-1))	0.000765	0.000370	2.068890	0.0511
***∆(EXCH(-2))	-0.001765	0.000379	-4.659486	0.0001
∆(INF)	-0.000634	0.000500	-1.266785	0.2191
***∆(INF(-1))	-0.001670	0.000445	-3.749716	0.0012
***∆(LGOV)	0.176378	0.041055	4.296196	0.0003
***∆(LGOV(-1))	-0.166058	0.052606	-3.156655	0.0048
***∆(RIR)	-0.005104	0.000724	-7.051327	0.0000
***∆(RIR(-1))	-0.004501	0.000710	-6.335269	0.0000
**∆(RIR(-2))	-0.000974	0.000397	-2.450915	0.0231
***ECM(-1)	-0.609712	0.018145	-11.55773	0.0000
R-squared	0.881510			
Adjusted R-squared	0.835937			
Durbin-Watson stat	2.379451			

Model II

ECM Regression				
Dependent Variable: ∆(LAGR)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆(LAGR(-1))	0.176193	0.121191	1.453849	0.1589
*∆(LAGR(-2))	-0.203417	0.110329	-1.843741	0.0776
∆(EXCH)	-0.000273	0.000376	-0.726735	0.4744
**∆(EXCH(-1))	-0.000993	0.000437	-2.273196	0.0323
∆(LGOV)	0.032774	0.053437	0.613322	0.5454
∆(LGOV(-1))	-0.012654	0.054642	-0.231580	0.8188
***∆(LGOV(-2))	-0.159110	0.053376	-2.980902	0.0065
***ECM(-1)	-0.580608	0.024226	-7.867978	0.0000
R-Squared	0.697451			
Adjusted R-Squared	0.624422			
Durbin-Watson stat	2.068491			

** indicates 10% level of significance; ** indicates 5% level of significance; *** indicates 1% level of significance*

Table 5. Post estimation diagnostics

Model I

DIagnostic Tests	**Normality Test**	**Serial Correlation LM Test**	**Heteroskedasticity Test: *Breusch-Pagan-Godfrey***
Test Statistics	*JB Stat*: 1.50	*F-Stat*: 1.555953	*F-Stat*: 0.468454
P Values	0.47	0.2367	0.9318

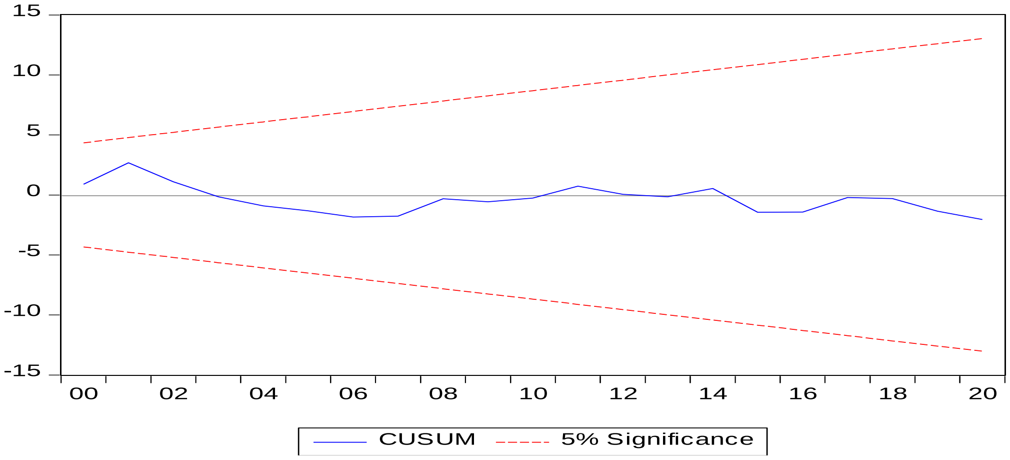
Model II

Diagnostic Tests	Normality Test	Serial Correlation LM Test	Heteroskedasticity Test: Breusch-Pagan-Godfrey
Test Statistics	*JB Stat*: 5.44	*F-Stat*: 1.067154	*F-Stat*: 1.841106
P Values	0.065	0.3606	0.0982

The null hypothesis of the Normality test states that the error terms of the estimated model are normally distributed, that of the LM test states that the error terms are not serially correlated while the that of ARCH test states that the error terms are homoscedastic. The P values of the respective test show that the null hypothesis for the test cannot be rejected at a 5% level of significance. This confirms the fulfilment of the basic assumptions of regression analysis about the characteristics of the error term. Thus, the inferences drawn from the estimated model are reliable.

Model Stability Test: This test is a graphical representation involving a pair of straight lines at a 0.05 significance level with the null hypothesis that the regression equation is correctly specified. The decision rule is to accept the null hypothesis if the plotted CUSUM graph remains inside the straight lines, otherwise reject it. Now, since our graph is inside the straight line for the two models as shown below, we will accept the null hypothesis and conclude that the regression equation is correctly specified.

Model I



Model II

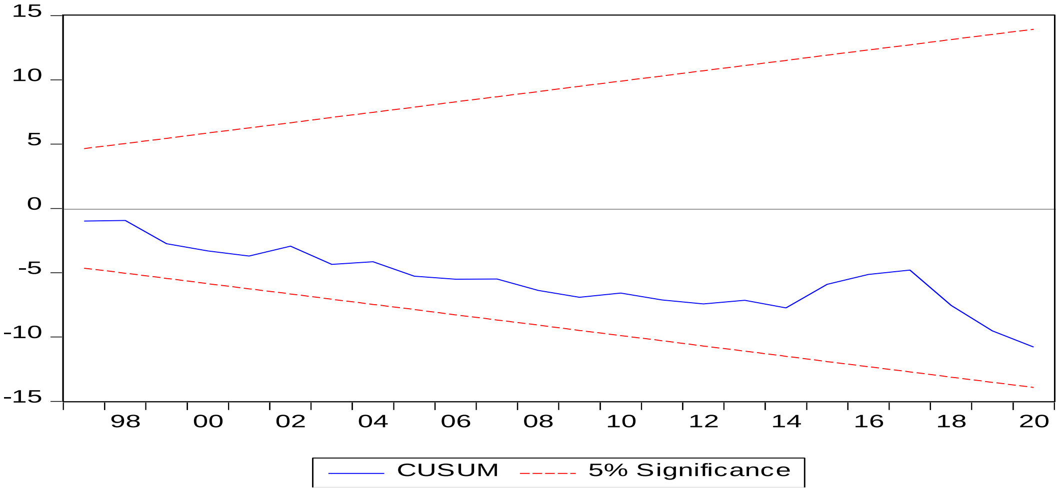


Fig. 2. Model stability test

5. CONCLUSION

The findings of this study show that the impact of exchange rate depreciation on industrial and agricultural output is fairly similar as exchange rate depreciation has a negative effect on industrial and agricultural output in the short run and a positive effect in the long run. The short-run negative impact of exchange rate depreciation on both industrial and agricultural output suggests that in the immediate aftermath of a currency devaluation, these sectors experience reduced output levels, likely due to increased costs of imported inputs and machinery, leading to higher production costs and decreased competitiveness of domestic industries. Similarly, in the agriculture sector, higher costs for imported fertilizers or equipment can constrain output.

The observation that certain variables initially show negative effects but turn positive in the long run reflects the dynamics of adjustment and adaptation in the economy. In the short run, factors like increased costs or reduced demand due to exchange rate changes might lead to lower output. However, in the long run, firms and farmers may adapt by finding alternative suppliers, adjusting production techniques, or exploring new markets. This adaptation process can gradually reverse the negative impacts observed in the short term, highlighting the flexibility and resilience of economic agents in responding to changing economic conditions.

The findings of this study underscore the importance of considering both short-run dynamics and long-run adjustments in understanding the effects of exchange rate depreciation and other economic variables on industrial and agricultural output.

6. RECOMMENDATIONS

Following the findings of this study, the following are the policy recommendations:

1. The high exchange rate volatility needs to be checked to enable realistic forecasts and good decision-making. Given the negative short-term impact of exchange rate depreciation on both industrial and agricultural output, policymakers should focus on measures to stabilize and manage exchange rates during periods of depreciation. This can include interventions by central banks to moderate volatility and prevent abrupt depreciation that could disrupt economic activities in these sectors.
2. To leverage the potential positive effects of exchange rate depreciation in the long run, governments should prioritize structural reforms aimed at enhancing productivity and competitiveness in industrial and agricultural sectors. This could involve investments in technology, infrastructure, and human capital development.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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