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Exchange Rate volatility and Economic Growth in Nigeria; An ARCH and GARGH Approach

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Abstract

The exchange rate plays a great role in shaping economic growth dynamics in Nigeria, serving as a critical determinant of the country's competitiveness in the global market. This study examined the impact of exchange rate volatility and economic growth in Nigeria; An ARCH and GARGH Approach from 2010 to 2023 for this study. A quarterly data from Central bank statistical bulletins were used for this study. The Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models ARCH and GARGH model were used to examine exchange rate volatility, while the Autoregressive Distributed Lag (ARDL) model was used examined the impact of exchange rate volatility on economic growth in Nigeria. The result indicated that there is exchange rate is volatile in Nigeria economy, exchange rate volatility has a significant negative impact on Nigeria's economic growth in long run. However, in short run, exchange rate volatility appears to have a positive and significant impact on economic growth in Nigeria. The error correction term (ECT) coefficient is significant and negative, suggesting that any short-term disequlibrium from the long-run equilibrium will be corrected over time. The study concluded that exchange rate volatility has significant impact on economic growth in Nigeria. The study recommended that the government and financial institutions should facilitate the use of financial instruments such as forward contracts, currency swaps, and other risk-mitigation mechanisms to protect businesses from unpredictable exchange rate movements. Additionally, enhancing financial literacy on forex risk management among businesses can help sustain growth and investment in a volatile economic environment. Policymakers should implement robust monetary and fiscal policies to reduce excessive fluctuations. This includes maintaining adequate foreign exchange reserves, enhancing the effectiveness of the Central Bank's interventions in the forex market, and adopting exchange rate management policies that promote stability among other recommendations were made.

Keywords: ARDL, exchange rate Volatility, Economic Growth, Foreign direct Investment, Money Supply
JEL Classification:

Contribution to/Originality Knowledge
This research work contributes to existing body of knowledge by providing first empirical evidence on cost-saving effects of solar-powered systems compared to diesel and/or petrol powered alternatives among dry season farmers in Sokoto State, Nigeria.

1.0 Introduction

Economic growth serves as a fundamental barometer of a nation's prosperity and well-being, reflecting the expansion of its productive capacity and the improvement of living standards over time. It encompasses a broad spectrum of factors, including increases in gross domestic product (GDP), employment opportunities, technological advancements, and infrastructure development. Sustainable economic growth fosters poverty alleviation, social stability, and enhanced access to education and healthcare, contributing to overall human development. Moreover, it provides the fiscal resources necessary for governments to invest in critical sectors such as education, healthcare, and infrastructure, laying the groundwork for future

prosperity. Effective policy frameworks that prioritize innovation, entrepreneurship, and equitable distribution of wealth are essential for nurturing robust and inclusive economic growth that benefits all segments of society (Olamide, et al, 2022).

Economic growth in Nigeria presents a dynamic economy shaped by a myriad of opportunities and challenges. As Africa's largest economy, Nigeria possesses abundant natural resources, a youthful population, and a growing middle class, all of which fuel its potential for sustained development. However, the economy is susceptible to volatility stemming from its heavy reliance on oil exports, infrastructure deficiencies, and institutional constraints. Addressing these challenges requires concerted efforts to diversify the economy, enhance productivity, and foster a conducive business environment. Initiatives aimed at promoting inclusive growth through investments in education, healthcare, and entrepreneurship are crucial for harnessing Nigeria's demographic dividend and unlocking its full economic potential. Strategic policy interventions, coupled with effective governance and private sector engagement, are essential for steering Nigeria towards a path of sustainable and inclusive economic growth that benefits all its citizens (Moses, et al, 2020).

The exchange rate is a crucial indicator in the global financial system, representing the value at which one currency is exchanged for another. It significantly impacts a country's economic competitiveness by influencing trade, investment, and overall financial stability. Exchange rates are shaped by various factors, including interest and inflation rates, geopolitical developments, and market sentiment, reflecting the relative strength of different economies. To manage exchange rates, governments and central banks implement policies aimed at fostering economic growth, ensuring price stability, and mitigating external risks. Moreover, exchange rates are key in international trade, affecting the cost and demand for goods and services across nations. Understanding these fluctuations is vital for businesses, policymakers, and individuals navigating the global economy (Din et al., 2024).

Exchange rate dynamics, particularly volatility, exert profound influences on Nigeria's economic landscape. As a major oil exporter, Nigeria's economy is heavily dependent on fluctuations in global oil prices, rendering its exchange rate vulnerable to external shocks. Exchange rate volatility can disrupt trade flows, escalate inflationary pressures, and hamper investor confidence, thereby impeding economic stability and growth prospects. Furthermore, the country's import-dependent nature amplifies the impact of currency fluctuations on consumer purchasing power and production costs. Effective management of exchange rate volatility through prudent monetary policies, flexible exchange rate regimes, and bolstering foreign exchange reserves is essential for mitigating economic risks and fostering sustainable development in Nigeria (Iliyasu, et al, 2024).

Exchange rate volatility presents a significant challenge to Nigeria's economic growth trajectory, given its heavy reliance on oil exports and import-dependent nature. Fluctuations in global oil prices often translate into sharp movements in the Nigerian Naira, disrupting trade patterns, increasing production costs, and undermining investor confidence. High exchange rate volatility can exacerbate inflationary pressures, limit foreign investment inflows, and hinder the development of domestic industries, ultimately impeding sustainable economic

growth. Furthermore, the uncertainty surrounding exchange rates complicates long-term planning for businesses, dampens consumer confidence, and erodes purchasing power, contributing to economic instability (Ehikioya, 2019).

Mitigating exchange rate volatility requires a multifaceted approach involving prudent fiscal and monetary policies, enhanced diversification efforts, and strengthened institutional frameworks. Nigeria needs to reduce its dependency on oil exports by diversifying its economy into non-oil sectors such as agriculture, manufacturing, and services. Additionally, implementing flexible exchange rate regimes and building adequate foreign exchange reserves can help cushion the economy against external shocks, while promoting greater transparency and accountability in monetary policy decision-making can enhance market confidence and stability. By addressing these challenges and fostering a conducive environment for investment and growth, Nigeria can navigate exchange rate volatility more effectively and foster sustained economic development. In view of the above, this study seeks to examine Exchange Rate volatility and Economic Growth in Nigeria; An ARCH and GARGH Approach. The main objective of this study is to examine the nexus between Exchange Rate volatility and Economic Growth in Nigeria. The specific objectives are to: Determine the exchange rate volatility; examine the short run impact of exchange rate volatility on economic growth; and to assess the long-run impact of exchange rate on economic growth in Nigeria.

2.0 Literature Review

2.1 Conceptual Review

2.1.1 Economic Growth

Economic growth is the continuous rise in an economy's production of goods and services over time (Aloun, 2024). This definition highlights the quantitative nature of growth, emphasizing the expansion of productive capacity, which is commonly measured through indicators like Gross Domestic Product (GDP) or Gross National Product (GNP). To Aisyah, et al(2024), economic growth can also be defined as the long-term increase in per capita income or GDP per capita. This perspective highlights the importance of growth in enhancing individual purchasing power and standards of living, as higher incomes provide individuals with greater economic opportunities and resources to meet their needs and aspirations.

Economic growth entails improvements in productivity and efficiency across various sectors of the economy(Iskandar, et al, 2023). This definition underscores the role of technological advancements, innovation, and investment in human and physical capital in driving increases in output per unit of input, thereby fostering economic progress and development.

2.1.2 Exchange Rate Volatility

Exchange rate volatility refers to the degree of variability or fluctuations in the value of a currency relative to another currency over a certain period of time. It measures the extent to which exchange rates deviate from their average or expected levels, reflecting the uncertainty and unpredictability in currency markets. High levels of exchange rate volatility can create challenges for businesses engaged in international trade or investment, as it introduces

uncertainty in pricing, revenue, and profit calculations (Bosupeng, et al, 2024). Exchange rate volatility also represents the level of risk and uncertainty associated with holding or transacting in foreign currencies. Sharp and unpredictable movements in exchange rates can expose individuals, businesses, and governments to financial losses or unexpected costs, especially if they are not adequately hedged against currency risk. Exchange rate volatility is a source of concern for policymakers as it can undermine economic stability, disrupt trade flows, and affect investor confidence, thereby impacting overall economic performance (Aftab, et al, 2024).

Exchange rate volatility can be quantitatively measured using statistical techniques such as standard deviation, variance, or volatility models such as ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity). These models analyze historical exchange rate data to estimate the level of volatility and assess the likelihood of future movements in exchange rates. Exchange rate volatility measures provide valuable insights for investors, policymakers, and risk managers in managing currency risk and making informed decisions in international financial markets (Yussif, et al, 2024).

2.2 Theoretical Review

2.2.1 Purchasing Power Parity (PPP) Theory

The concept of PPP has its roots in the writings of economists such as David Ricardo. However, Gustav Cassel in (1918) developed the PPP theory. Purchasing Power Parity theory asserts that in the long run, exchange rates between two currencies should equalize the prices of a basket of goods and services in both countries when expressed in the same currency. Essentially, it suggests that exchange rates adjust to ensure that identical goods cost the same amount in different countries. If a product costs more in one country when converted into another currency, arbitrage opportunities arise, leading to adjustments in exchange rates. PPP serves as a fundamental concept in international economics, guiding discussions on exchange rate determination and long-term currency valuation (Gwaison, 2021).

Purchasing Power Parity (PPP) Theory posits that in the long run, exchange rates between countries should equalize the prices of a basket of goods and services. In the context of Nigeria, understanding PPP is crucial for assessing whether the country's currency is overvalued or undervalued relative to other currencies. If exchange rate volatility deviates significantly from PPP, it could signal imbalances in the Nigerian economy, impacting its economic growth. Persistent deviations might lead to adjustments in trade balances and investment flows, affecting the overall economic stability (Gwaison & Apeh , 2021).

2.2.2 Optimal Currency Area (OCA) Theory

The concept of optimal currency areas was first introduced by economist Robert Mundell in his seminal paper "A Theory of Optimum Currency Areas" published in 1961. Mundell's work laid the foundation for understanding the conditions under which countries would benefit from sharing a common currency. Mckinnon (1963) also contributed to the development of the

theory. The Optimal Currency Area theory evaluates the conditions under which a group of countries could optimally share a common currency. It suggests that for a currency union to be effective, participating countries should have similar economic structures, mobility of factors of production, and a mechanism to absorb asymmetric shocks. The theory helps policymakers understand the benefits and challenges of forming a currency union, such as the Eurozone, by considering factors like labor market flexibility, fiscal integration, and economic synchronization (Gwaison & Apeh, 2021).

Optimal Currency Area (OCA) Theory evaluates the suitability of a single currency across different regions based on factors like economic integration, labor mobility, and fiscal policy coordination. Nigeria, with its diverse economic regions, could benefit from analyzing OCA theory concerning its currency, the Naira. If exchange rate volatility hinders economic integration or if the regions have different economic structures and needs, it may impact Nigeria's growth trajectory. Assessing the Naira's role within the OCA framework can provide insights into managing exchange rate volatility to foster economic growth (Gwaison, 2021).

2.3 Empirical Review

Din et al (2024) explored the complex interplay among exchange rate fluctuations, inflation, and economic growth across South Asian nations from 1990 to 2021. Employing a diverse array of econometric techniques and models, including GARCH and FGLS regression, the research underscores the adverse impact of exchange rate volatility on economic growth, while inflation's effect is deemed statistically insignificant. Notably, the study advocates for policies aimed at fostering exchange rate stability to promote sustained economic growth, offering specific recommendations to policymakers.

Boboye and Ezekiel (2023) examined the nexus between foreign exchange fluctuations and economic growth in Nigeria, this study covers the period from 1989 to 2020, employing various statistical analyses. Notably, it finds that while balance of payment exerts a negative but insignificant effect on economic growth, exchange rate positively and significantly influences economic growth in both short and long run. Conversely, trade openness is found to have a negative significant effect on economic growth. Consequently, the study recommends measures to regulate exchange rates, manage inflation trends, and promote export-led growth to foster sustainable economic development.

Olamide et al (2022) investigated the impact of exchange rate instability on the inflation-growth nexus from 2000 to 2018, utilizing techniques such as PMG and GARCH. It reveals a negative relationship between exchange rate instability, inflation, and economic growth, emphasizing the adverse consequences of instability on the region's growth prospects. Consequently, the study advocates for policies aimed at appreciating local currencies to mitigate the adverse effects of exchange rate instability on inflation and economic growth.

Moses et al (2020) examined the effects of USD/NG₦ exchange-rate volatility on Nigeria's economic growth. Employing GARCH and VECM analyses using data from 2003 to 2017, the research finds a significant negative effect of USD/NG₦ volatility on the country's GDP

growth, with short-term unidirectional causality between volatility and economic growth. Notably, the study highlights the limited impact of the interbank exchange rate on economic growth, suggesting access constraints within the productive sector.

Adeniyi and Olasunkanmi (2019) examined the impact of exchange rate volatility on economic growth in Nigeria using ARDL cointegration and Error Correction Models. The findings indicate a significant impact of exports on GDP, while imports are found to be insignificant. Additionally, the study reveals an insignificant positive relationship between exchange rate volatility and economic growth, suggesting the need for economic diversification and stability in exchange rates to foster sustainable growth.

Despite extensive research on exchange rate volatility and economic growth in Nigeria and other regions, significant gaps remain. Existing studies have produced mixed findings, with some highlighting the negative impact of exchange rate volatility on economic growth (Moses et al., 2020; Olamide et al., 2022), while others suggest a positive or insignificant relationship (Boboye & Ezekiel, 2023; Adeniyi & Olasunkanmi, 2019). Thus, there is need for this study. Additionally, prior research has largely focused on exchange rate fluctuations without adequately addressing the role of policy measures in mitigating volatility's adverse effects on economic growth. Furthermore, existing literature does not sufficiently explore sectoral impacts or the implications of exchange rate instability for Nigeria's broader macroeconomic framework. This study aims to bridge these gaps by employing ARCH and GARGH models to provide a more robust analysis of exchange rate volatility and its implications for Nigeria's economic growth.

3.0 Methodology

3.1 Research Design

This study employed ex-post facto research design. Ex-post facto research design, also known as a retrospective or causal-comparative design, involves the study of relationships between variables after events have occurred, without direct manipulation by the researcher. This design leverages existing data to analyze the effects of naturally occurring differences in independent variables on dependent variables. In the context of a study on exchange rate volatility and economic growth in Nigeria, an ex-post facto design would entail examining historical data on exchange rates, economic indicators, and other relevant variables to understand how fluctuations in exchange rates have influenced economic growth over time.

3.2 Nature and Sources of Data

The nature and source of data for studying exchange rate volatility and economic growth in Nigeria typically involve collecting secondary data (quarterly time-series data) from central banks of Nigeria and National bureau of statistics from 2010-2023.

3.3 Model Specification

The Autoregressive Conditional Heteroskedasticity (ARCH) model, introduced by Robert Engle in 1982, is used to model time series data where the variance of the errors (or the returns)

is not constant over time but instead depends on past periods' errors. Given a time, series yt the ARCH model can be expressed as mean equation (1):

$$y_t = \mu + \varepsilon_t \tag{1}$$

Where: y_t is the value of the time series at time t; μ is the mean of the series (which could be zero if the series is mean-corrected). ϵ_t is the error term (also called the residual). Variance equation is specified in equation (2):

$$\varepsilon_t = \delta.zt \tag{2}$$

Where: σ_t^2 is the conditional variance of the error term at time t. z_t is a white noise process with mean zero and variance one $(ie.zt: N(0,1)\alpha_0 > 0 and \alpha i \geq 0 for i = 1,2...q$ to ensure the variance is non-negative. q is the order of the ARCH model, which indicates how many lagged squared errors are used to model the variance.

The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, developed by Tim Bollerslev in 1986, is an extension of the ARCH model. It allows the conditional variance to depend not only on past squared errors but also on past conditional variances.

$$y_t = \mu + \grave{o}_t \tag{3}$$

Variance Equation: $\varepsilon_t = \delta.zt$

$$\delta^2{}_t = \alpha_0 + \sum_{i=1}^{q} \alpha_1 \varepsilon^2{}_{t-i} + \sum_{j-1}^{p} \beta_j \delta^2{}_{t-j} \tag{4}$$

Where: σ_t^2 is the conditional variance at time t. z_t is a white noise process with mean zero and variance one $(ie.zt: N(0,1)\alpha_0 > 0 and \alpha i \geq 0 and \beta_j \geq 0)$ to ensure the variance is non negative. q is the number of lagged squared errors in the model. p is the number of lagged conditional variances in the model. α_i measures the impact of past squared errors on the current variance. βj measures the impact of past conditional variances on the current variance.

Essentially, the ARCH model captures volatility clustering by accounting for the influence of past shocks (errors), while the GARCH model builds on this by incorporating the persistence of volatility through past conditional variances. Various indicators are used to assess economic growth, with this study focusing on Gross Domestic Product (GDP). Additionally, numerous macroeconomic variables influence economic growth beyond exchange rate volatility, which will be included to enhance the model's accuracy. Drawing from this theoretical foundation, the study will estimate the following relationship.

$$GDP = f\left(EXVOL, FDI, OP, INFR, MS\right) \tag{5}$$

Where: GDP: Real Gross Domestic Product, EXVOL is exchange rate volatility, FDI is foreign direct investment, OP is international oil price, MS is money supply and INF is inflation rate.

An Autoregressive Distributed Lag (ARDL) model can be specified as follows:

$$\begin{aligned}\Delta GDP_t = \alpha_0 + i = 0\sum_{i=0}^{p} \alpha i GDP_{t-1} + \sum_{i=0}^{q1} \beta_1 EXVOL_{t-1} + \sum_{i=0}^{q2} \beta_2 FDI_{t-1} \\ + \sum_{i=0}^{q3} \beta_3 OP_{t-1} + \sum_{i=0}^{q4} \beta_4 INFR_{t-1} + \sum_{i=0}^{q5} \beta_5 MS_{t-1} + \lambda_1 EXVOL_{t-1} + \lambda_2 FDI_{t-1} \\ + \lambda_3 OP_{t-1} + \lambda_4 INFR_{t-1} + \lambda_5 MS_{t-1} + \lambda_6 GDP_{t-1} + \mu_t\end{aligned} \quad (6)$$

Where: Δ represents the first difference of the variable. p and q are the optimal lags for each variable as determined by some criteria (e.g., AIC, BIC). α0 is the intercept. λ represent the long-run coefficients. μt is the error term.

This ARDL model allows the examination of both short-run and long-run relationships between GDP and its determinants. The short-run dynamics are captured by the first differenced variables, while the long-run relationship is reflected by the levels of the lagged variables. The long-run relationship in an ARDL model can be specified as:

$$Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=1}^{q} \theta_j X_{t-j} + \varepsilon_t \quad (7)$$

Where: Yt is the dependent variable (e.g., economic growth in Nigeria). Xt−j represents the independent variable(s) (e.g., exchange rate volatility). β0 is the intercept. βi and θj are the long-run coefficients. p and q are the optimal lag lengths for Yt and Xt, respectively. εt is the error term. The short-run ARDL model is derived from the long-run equation and incorporates dynamic changes:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \delta_j \Delta X_{t-j} + \lambda ECT_{t-1} + \mu_t \quad (8)$$

Where: Δ represents the first difference operator. α0 is the intercept. αi and δj capture the short-run dynamics. ECTt−1 is the error correction term obtained from the long-run equation. λ is the speed of adjustment coefficient, which should be negative and significant to confirm the existence of a stable long-run relationship. μt is the error term. The ECM captures the speed at which disequilibrium in the short-run is corrected in the long-run:

$$\Delta Y_t = \gamma_0 + \sum_{i=1}^{p-1} \gamma_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \eta_j \Delta X_{t-j} + \phi ECT_{t-1} + \nu_t \quad (9)$$

Where: ECTt−1 is the lagged error correction term derived from the long-run relationship. ϕ is the speed of adjustment parameter, expected to be negative and statistically significant. νt is the residual term. These models allow for the estimation of both short-run and long-run effects

of exchange rate volatility on economic growth while accounting for disequilibrium adjustments over time.

3.4 Data and Sources of Data Collection

Although the key variable of interest is FD, there are other factors that need to be accounted for to avoid endogeneity problems. As such, variables that are known to impact public sector employment in each local government are included as control variables.

Table 1: Variables and Definitions

Variable	Symbol	Measurement
Gross Domestic Product	GDP	Measured in constant local currency units (billions of Naira). Represents the total value of goods and services produced in a country, adjusted for inflation.
Exchange Rate Volatility	EXVOL	Measured as the standard deviation or percentage change in the exchange rate (e.g., Naira per USD) over a specific period (quarterly).
Foreign Direct Investment	FDI	Measured as the net inflows of investment from foreign investors, usually in millions or billions of USD, relative to GDP.
International Oil Price	OP	Measured in USD per barrel. Represents the average price of crude oil in the international market.
Inflation Rate	INFR	Measured as the percentage change in the Consumer Price Index (CPI) over a specified period (quarterly inflation rate).
Money Supply	MS	Measured in millions or billions of local currencies (Naira). Refers to the total amount of monetary assets available in an economy at a specific time, often using M2 or M3 as indicators.

3.5 Data Analysis Technique

To analyse the relationship between exchange rate volatility and economic growth in Nigeria, researchers commonly utilize ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) models to account for time-varying exchange rate fluctuations. The ARCH model initially identifies volatility clustering, where periods of high volatility follow similar patterns. If such clustering is significant, the GARCH model is applied to model and forecast the conditional variance of exchange rate movements. This method provides a deeper insight into how exchange rate volatility influences economic growth over time, reflecting the dynamic nature of financial markets. Additionally, the ARDL (Auto-Regressive Distributed Lag) model is employed to investigate the long-term and short term relationship between exchange rate volatility and economic growth in Nigeria.

4.0 Results, Findings and Discussion

Table 2: Descriptive Statistics

Variables	GDP	EXVOL	FDI	OP	INFR	MS
Mean	27072.21	254.0648	3.55E+09	70.33980	12.86447	22325.54
Median	24627.75	253.4920	2.85E+09	65.23000	12.28000	20078.14
Maximum	50102.70	425.9800	8.84E+09	97.98000	19.21000	46495.04
Minimum	12790.38	150.3000	-1.87E+08	39.68000	8.050000	10907.30
Std. Dev.	9805.221	93.80762	2.47E+09	20.22470	3.066363	9221.591
Skewness	0.517570	0.320060	0.600529	0.071148	0.273876	0.931483
Kurtosis	2.299972	1.681691	2.260200	1.396520	2.231241	3.108072

Jarque-Bera	3.188170	4.384870	4.062595	5.290767	1.819172	1.109741
Probability	0.203094	0.111645	0.131165	0.070978	0.402691	0.128585
Sum	1326538.	12449.17	1.74E+11	3446.650	630.3590	1093951.
Sum Sq. Dev.	4.61E+09	422393.7	2.93E+20	19633.86	451.3239	4.08E+09
Observations	49	49	49	49	49	49

Source: Authors Computation E-view 12.0

Table 2 presents the descriptive statistics for the variables under study, including GDP, exchange rate volatility (EXVOL), foreign direct investment (FDI), openness (OP), inflation rate (INFR), and money supply (MS). The mean represents the average value of each variable over the 49 observations, with GDP averaging 27,072.21, EXVOL at 254.06, and FDI at approximately 3.55 billion. The median, which is the middle value, is slightly lower than the mean for most variables, suggesting a slight rightward skew in the data distribution. The maximum and minimum values show the highest and lowest recorded observations, respectively, highlighting the range of variability within the dataset. For instance, GDP ranges from 12,790.38 to 50,102.70, indicating significant economic fluctuations over time. The standard deviation measures the dispersion of data from the mean, with GDP having the highest variability (9,805.22), suggesting considerable economic fluctuations, while EXVOL (93.81) and INFR (3.07) exhibit relatively lower dispersion. These statistics provide insights into the distribution and variability of the variables, which are crucial for further econometric analysis. The Jarque-Bera statistic in Table 1 tests whether the dataset's skewness (asymmetry) and kurtosis (tail heaviness) match a normal distribution. For each variable in your table (GDP, EXVOL, FDI, OP, INFR, MS), the Jarque-Bera values (3.188170, 4.384870, 4.062595, 5.290767, 1.819172, 1.109741) with their corresponding probabilities (0.203094, 0.111645, 0.131165, 0.070978, 0.402691, 0.128585) suggest that none of the variables significantly deviate from normality, as the probabilities are all above the conventional threshold (0.05). This indicates that the data distribution for each variable are normally distributed and can be used for further analysis.

The table 2 presents both the covariance and correlation matrix of six variables (GDP, EXVOL, FDI, OP, INFR, and MS). The covariance values show the direction of the linear relationship between pairs of variables, while the correlation values (ranging between -1 and 1) reveal the strength and direction of these relationships. For instance, there is a moderate positive correlation between EXVOL (exchange rate volatility) and MS (money supply) with a correlation coefficient of 0.948106, indicating that as exchange rate volatility increases, money supply also tends to increase.

Table 3: Correlation Matrix

Covariance Correlation	GDP	EXVOL	FDI	OP	INFR	MS
GDP	94180263					
	(1.000)					
EXVOL	859123.5	8620.280				
	(0.353)	(1.000)				
FDI	-1.55E+13	-1.53E+11	5.99E+18			
	(-0.153)	(-0.674)	(1.000)			
OP	-80742.82	-953.9761	3.20E+10	400.6910		
	(-0.416)	(-0.513)	(0.654)	(1.000)		
INFR	18954.11	216.7758	-3.48E+09	-24.54366	9.210693	
	(0.244)	(0.769)	(-0.469)	(-0.404)	(1.000)	
MS	85822298	803426.4	-1.39E+13	-59529.67	19653.34	83302274
	(0.269)	(0.948)	(-0.623)	(-0.326)	(0.710)	(1.000)

Source: Authors Computation E-view 12.0

In contrast, FDI (foreign direct investment) has a negative correlation with GDP and EXVOL (-0.153461 and -0.674227, respectively), suggesting that higher FDI is associated with lower GDP and exchange rate volatility. The correlation matrix provides insights into the relationships between the variables, helping identify how changes in one variable might affect others.

Table 3: Augmented Dickey-Fuller (ADF) Unit Root test

Variables	ADF Statistics	P-value	Order of integration	Remark
GDP	-7.185599	0.0000	1(1)	Stationarity at first difference
EXVOL	-5.277896	0.0000	1(0)	Stationarity at level
FDI	-9.627429	0.0000	1(1)	Stationarity at first difference
OP	-4.842819	0.0178	1(0)	Stationarity at level
INFR	-4.747376	0.0005	1(1)	Stationarity at first difference
MS	-5.451793	0.0419	1(1)	Stationarity at first difference

Source: Authors Computation E-view 12.0

The Table 3 presents the results of the Augmented Dickey-Fuller (ADF) unit root test applied to six variables (GDP, EXVOL, FDI, OP, INFR, and MS). The ADF statistics and their corresponding p-values test for stationarity, determining if a series has a unit root (non-stationary) or not. A significant p-value (less than 0.05) indicates stationarity. The results reveal that EXVOL (exchange rate volatility) and OP (oil prices) are stationary at the level, as their p-values are significant without differencing (1(0)). Conversely, GDP, FDI, INFR (inflation rate), and MS (money supply) exhibit stationarity only after the first difference (1(1)), implying they are initially non-stationary but become stationary after differencing. The mixture of 1(0) and 1(1) suggest the used of ARDL model for subsequent econometric analysis.

Table 4: Cointegration Bound Test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.774202	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

Source: Authors Computation E-view 12.0

The Cointegration Bound Test Table 4 assesses whether a long-run equilibrium relationship exists among the variables. The F-statistic value (9.774202) is compared against the critical values at different significance levels (10%, 5%, 2.5%, and 1%) for both I(0) (no cointegration) and I(1) (cointegration). Since the F-statistic exceeds the upper bound critical values at all significance levels, it strongly suggests that the variables are cointegrated, indicating a stable long-term relationship among them. The value of K represents the number of regressors in the model, which is 5 in this case.

Table 5: Lag Selection Criteria Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2479.975	NA	3.53e+38	105.7862	106.0224	105.8750
1	-2064.975	706.3824	3.54e+31	89.65852	91.31184*	90.28068
2	-2009.308	80.53959*	1.65e+31*	88.82162*	91.89208	89.97706*

Source: Authors Computation E-view 12.0

The Lag Selection Criteria Test in table 5 compares different lags (0, 1, 2) to determine the optimal lag length for the model based on several criteria: LogL (Log Likelihood), LR

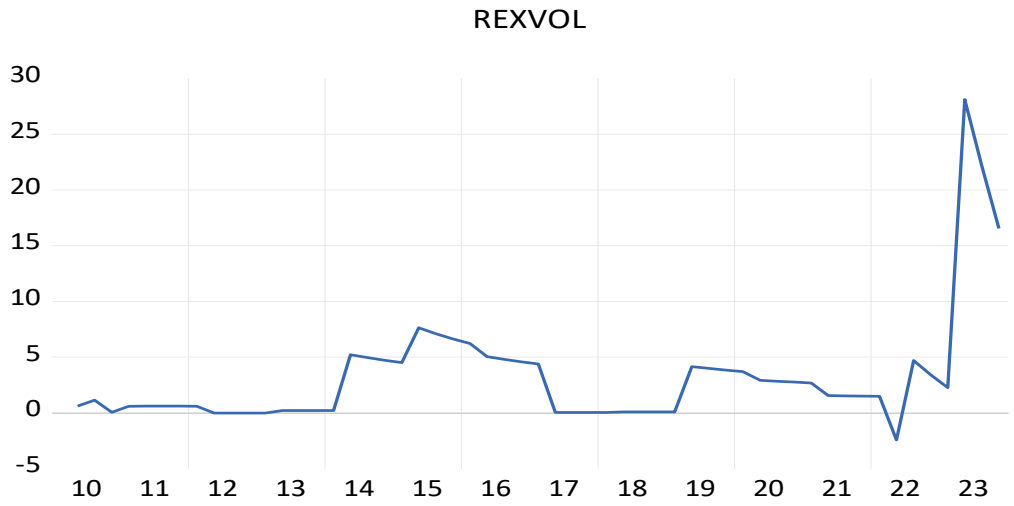
(Likelihood Ratio), FPE (Final Prediction Error), AIC (Akaike Information Criterion), SC (Schwarz Criterion), and HQ (Hannan-Quinn Criterion). The optimal lag is identified by the minimum values in these criteria. Here, the lag length 2 is indicated as the best choice since it has the lowest values for LR (80.53959), FPE (1.65e+31), AIC (88.82162), SC (91.89208), and HQ (89.97706), suggesting that it provides the best model fit compared to lags 0 and 1.

Table 6: ARCH Test for volatility

F-statistic	4.079554	Prob. F(1,51)	0.0000
Obs*R-squared	5.082545	Prob. Chi-Square(1)	0.0000

Source: Authors Computation E-view 12.0

The ARCH (Autoregressive Conditional Heteroskedasticity) test is used to detect volatility clustering in time series data. In the context of exchange rate volatility and economic growth in Nigeria, Table 6 provides the results of the ARCH test. The F-statistic (4.079554) and the Obs*R-squared value (5.082545), both with highly significant p-values (0.0000), indicate the presence of autoregressive conditional heteroskedasticity in the residuals. This suggests that there is significant volatility clustering in the exchange rate data, meaning periods of high volatility are followed by high volatility and periods of low volatility are followed by low volatility. Understanding this pattern can be crucial for modeling and forecasting economic growth and exchange rate dynamics in Nigeria.



Source: Authors Computation E-view 12.0

Figure 1: Graphical analysis of Volatility

The volatility test graph shows how exchange rate volatility has changed over time, with the x-axis representing the time or data points from 10 to 23, and the y-axis indicating the volatility levels ranging from -5 to 30. The graph reveals that volatility remained relatively stable and low for most of the observed period, but experienced a significant spike around the 22nd and 23rd data points, suggesting an important event or change in the underlying data causing this sudden increase in volatility. The figure 1 above indicated the evidence of exchange rate volatility clustering that is the period of high volatility are followed by period of tranquility

Estimation Test

Table 7: ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.533894	0.012563	42.49726	0.0000
REXVOL(-1)	0.784384	0.012708	61.72289	0.0000
Variance Equation				
C	5.351604	2.223349	2.407001	0.0161
RESID(-1)^2	-0.004476	0.368598	-0.012145	0.9903
RESID(-2)^2	0.014029	0.602406	0.023288	0.9814
GED PARAMETER	0.441874	0.079184	5.580364	0.0000

R-squared	0.464901	Mean dependent var	3.301525
Adjusted R-squared	0.454611	S.D. dependent var	5.299506
S.E. of regression	3.913711	Akaike info criterion	3.663016
Sum squared resid	796.4908	Schwarz criterion	3.884014
Log likelihood	-92.90143	Hannan-Quinn criter.	3.748246
Durbin-Watson stat	2.140784		

Source: Authors Computation E-view 12.0

This ARCH (Autoregressive Conditional Heteroskedasticity) model is used to analyze the volatility (REXVOL) of a time series over a specified period (2010Q3 to 2023Q4). The model employs the Maximum Likelihood ARCH method with a Generalized Error Distribution (GED), and the parameters are optimized using BFGS and Marquardt steps. It includes both a mean equation, which shows that the current volatility (REXVOL) is influenced by its previous value (REXVOL(-1)), and a variance equation, which models the variance (volatility) as a function of past squared residuals (errors). The model also includes GED parameter estimation for more flexibility. The model shows significant coefficients for the constant term (C) and the lagged dependent variable, indicating strong persistence in volatility. However, the squared residuals from previous periods (RESID(-1)^2 and RESID(-2)^2) are not significant, suggesting that recent past shocks do not greatly impact current volatility. The overall fit of the model is modest, with an adjusted R-squared of 0.454611, indicating that around 45.5% of the variation in volatility can be explained by this model.

Table 8: GARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.022686	0.002599	8.727509	0.0000
REXVOL(-1)	0.882579	0.015038	58.68904	0.0000
Variance Equation				

C(3)	2.450666	2.024231	1.210665	0.2260
C(4)	0.755919	4.819363	0.156850	0.8754
C(5)	-0.046779	4.388532	-0.010659	0.9915
C(6)	0.037749	0.621105	0.060777	0.9515
GED PARAMETER	0.221182	0.033116	6.678966	0.0000

R-squared	0.439133	Mean dependent var	3.301525
Adjusted R-squared	0.428347	S.D. dependent var	5.299506
S.E. of regression	4.006835	Akaike info criterion	2.632855
Sum squared resid	834.8458	Schwarz criterion	2.890687
Log likelihood	-64.08709	Hannan-Quinn criter.	2.732291
Durbin-Watson stat	2.254159		

Source: Authors Computation E-view 12.0

This GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model aims to analyze the volatility (REXVOL) of a time series, employing Maximum Likelihood estimation with Generalized Error Distribution (GED) for flexibility. The model includes both a mean equation showing that the current volatility is significantly influenced by its past value (REXVOL(-1)) and a variance equation, which models the log of conditional variance (GARCH) as a function of past residuals standardized by their respective conditional variances and the past log variance. Despite having significant coefficients in the mean equation, the coefficients in the variance equation are not statistically significant, indicating that past volatility influences do not strongly contribute to current volatility in this case. The model exhibits an adjusted R-squared of 0.428347, indicating that around 42.8% of the variation in volatility is explained by this model. The GED parameter indicates the model's adaptability to the data distribution, while the Durbin-Watson statistic suggests no severe autocorrelation in the residuals.

Based on the adjusted R-squared values, the ARCH model (0.454611) explains slightly more variability in the data compared to the GARCH model (0.428347). Thus, the ARCH model appears to be a better fit for capturing the volatility in this case. Using the Schwarz Information Criterion (SIC), the ARCH model has a SIC value of 3.884014, while the GARCH model has a lower SIC value of 2.890687. Hence, the GARCH model is the better fit because a lower SIC value indicates a better model fit.

Table 9:ARDL Long-Run Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REXVOL	-616.5041	148.4932	-4.151733	0.0002
FDI	1.51E-07	1.43E-07	1.049151	0.3015
OP	-110.5349	15.95051	-6.929864	0.0000
INFR	-125.3314	124.3541	-1.007859	0.3206
MS	1.082687	0.055589	19.47671	0.0000
C	13765.14	1562.715	8.808479	0.0000

Source: Authors Computation E-view 12.0

This ARDL (Autoregressive Distributed Lag) long-run form in Table 9 analyzes the impact of various factors on GDP. The negative coefficient for REXVOL (-616.5041) with high significance (p=0.0002) suggests that higher volatility reduces GDP. FDI shows a positive but

insignificant effect on GDP. The negative coefficient for OP (-110.5349) with high significance (p=0.0000) implies that an increase in OP decreases GDP. INFR's effect on GDP is negative but not significant. MS has a positive and highly significant impact on GDP, indicating that an increase in MS significantly boosts GDP. The constant term (C) is also highly significant, representing the baseline level of GDP.

Table 10: ARDL Short-Run Form

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	0.576476	0.111404	5.174638	0.0000
D(OP)	29.69108	143.8754	0.206367	0.8377
D(REXVOL(-1))	315.7623	144.5948	2.183773	0.0360
D(MS)	1.209026	0.191133	6.325580	0.0000
D(FDI)	-1.739318	0.205984	-8.443931	0.0000
CointEq(-1)*	-0.544997	0.127622	-8.971813	0.0000

R-squared	0.792815	Mean dependent var	682.3054
Adjusted R-squared	0.766917	S.D. dependent var	2533.238
S.E. of regression	1223.014	Akaike info criterion	17.17713
Sum squared resid	59830499	Schwarz criterion	17.41565
Log likelihood	-389.0740	Hannan-Quinn criter.	17.26648
Durbin-Watson stat	2.341550		

Source: Authors Computation E-view 12.0

This ARDL (Autoregressive Distributed Lag) short-run form table with GDP as the dependent variable examines the short-term relationships between GDP and various factors. The lagged GDP (D(GDP(-1))) is highly significant, indicating strong persistence in GDP over time. The significant positive coefficient for D(REXVOL(-1)) implies that past volatility positively affects GDP in the short run. The money supply (D(MS)) also shows a significant positive impact on GDP, while foreign direct investment (D(FDI)) has a significant negative effect. The error correction term (CointEq(-1)) is significant and negative, suggesting that any short-term deviations from the long-run equilibrium will be corrected over time. The model fits well, with an adjusted R-squared of 0.766917, indicating that approximately 76.7% of the variability in GDP is explained by the model.

Post Estimation Test

Table 11: Post estimation test Results

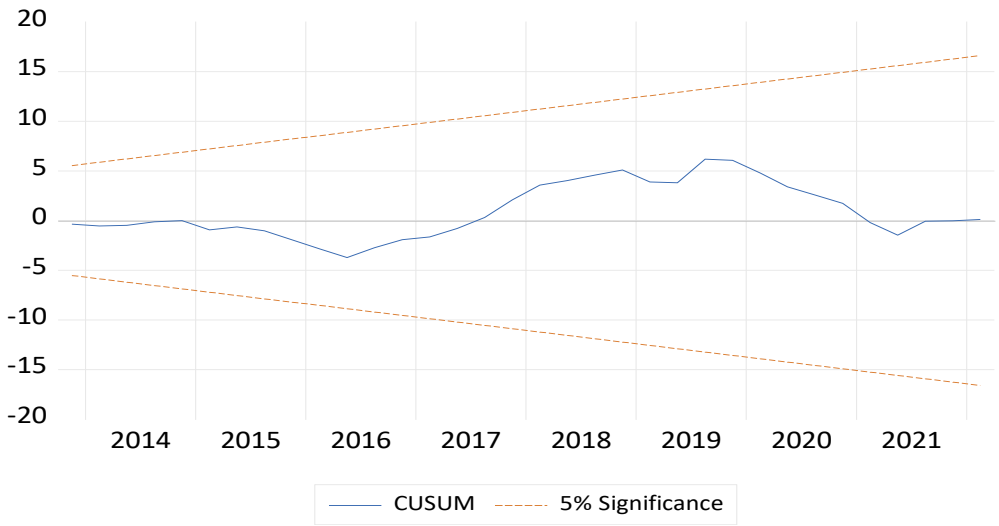
Test	**Statistics**	**P-value**
Normality Test	5.598592	0.060853
Breusch-Godfrey L. M. Test	1.077568	0.3525
Breusch-Pagan Heteroskedasticity Test	1.663424	0.3525

Sign-Bias	0.404829	0.6874
Negative-Bias	-0.576745	0.5668
Positive-Bias	-0.423709	0.6736
Joint-Bias	1.170447	0.7606

Source: Authors Computation E-view 12.0

This normality test examines the distribution of the residuals from your dataset to determine if they follow a normal distribution. The histogram and Jarque-Bera test result, with a probability value of 0.060853, suggest that the residuals are approximately normally distributed. The Breusch-Godfrey Serial Correlation LM Test is used to detect serial correlation in the residuals of a regression model. The results show a high p-value (Prob. F(2,32) = 0.3525 and Prob. Chi-Square(2) = 0.2343), indicating that there is no significant evidence of serial correlation at up to 2 lags, thus supporting the null hypothesis. The Breusch-Pagan-Godfrey Heteroskedasticity Test checks for homoskedasticity, i.e., constant variance of the errors in a regression model. The results, with high p-values (Prob. F(11,34) = 0.1251, Prob. Chi-Square(11) = 0.1377, and Prob. Chi-Square(11) for Scaled Explained SS = 0.1301), indicate that there is no significant evidence of heteroskedasticity, thus supporting the null hypothesis of homoskedasticity.

The Engle-Ng Sign-Bias Test assesses the presence of leverage effects (asymmetries in volatility due to positive and negative shocks) in the standardized residuals of a time series model. The test produces statistics for sign-bias, negative-bias, positive-bias, and joint-bias, with corresponding p-values. In this case, all the p-values (Sign-Bias: 0.6874, Negative-Bias: 0.5668, Positive-Bias: 0.6736, Joint-Bias: 0.7606) are high, suggesting that none of these biases are statistically significant. Therefore, we fail to reject the null hypothesis, indicating there are no significant leverage effects in the standardized residuals.



Source: Authors Computation E-view 12.0

Figure 2: CUSUM test

This figure is a Cumulative Sum (CUSUM) control chart, which is used to monitor the stability of a process over time. The x-axis represents the years from 2014 to 2021, while the y-axis represents the CUSUM values. The blue line indicates the CUSUM values, and the dashed orange lines represent the 5% significance limits. The CUSUM values fluctuate around zero, indicating that the process is generally stable, as the values remain within the significance

limits. This chart is relevant for identifying shifts or trends in the process, and it shows that there were no significant deviations from the expected process behavior during this period.

Statistical test of Hypothesis

H01: There is no exchange rate volatility in Nigeria.

The significant coefficients and p-values in both the ARCH and GARCH models in Table 7 and 8 suggest the presence of exchange rate volatility in Nigeria. Specifically, in the ARCH model, the lagged exchange rate volatility (REXVOL(-1)) has a coefficient of 0.784384 with a p-value of 0.0000, while in the GARCH model, the same variable has a coefficient of 0.882579 with a p-value of 0.0000. These results indicate that past exchange rate volatility significantly impacts current volatility, leading to the rejection of the null hypothesis H0, which states that there is no exchange rate volatility in Nigeria.

H02: Exchange rate volatility has no long-run impact economic growth in Nigeria. According to the long-run ARDL form, the coefficient for REXVOL is -616.5041 with a p-value of 0.0002, which is highly significant. Therefore, we reject the null hypothesis, indicating that exchange rate volatility has a significant negative impact on Nigeria's economic growth in the long run.

H03: Exchange rate volatility has no short-run impact on economic growth in Nigeria. The short-run ARDL form shows that the coefficient for D(REXVOL(-1)) is 315.7623 with a p-value of 0.0360, which is significant. Hence, we reject the null hypothesis, suggesting that exchange rate volatility has a significant positive impact on Nigeria's economic growth in the short run.

4.1 Discussions of Findings

The findings from the ARCH and GARCH models indicate a significant presence of exchange rate volatility in Nigeria. The highly significant coefficients for the lagged exchange rate volatility (REXVOL(-1)) in both models highlight the influence of past volatility on current fluctuations, suggesting that exchange rate movements in Nigeria are heavily influenced by their historical behavior. This persistence of volatility implies that external shocks and market speculations can have lasting impacts on the Nigerian economy, underscoring the importance of implementing robust monetary and fiscal policies to manage and mitigate such volatility. The results also emphasize the need for businesses and investors to develop strategies to hedge against exchange rate risks, ensuring stability and growth in the volatile economic landscape. This finding agreed with the work of Olamide et al (2022) that there is exchange rate volatility in Nigeria. It also agreed with the work of Moses et al (2020) that indicated that there is exchange rate volatility in Nigeria

The results from the ARDL long-run model show that exchange rate volatility has a significant negative impact on economic growth in Nigeria, as evidenced by the highly significant coefficient for REXVOL (-616.5041) with a p-value of 0.0002. This suggests that fluctuations in the exchange rate can create uncertainty, disrupt investment decisions, and ultimately hinder the overall economic growth in the long run. Policymakers should therefore consider implementing measures to stabilize the exchange rate to foster a more conducive environment for economic growth. This finding agreed with the work of Din, et al (2024) that exchange rate volatility has adverse impact on economic growth across South Asian nations from 1990 to 2021. Also Olamide et al (2022) agreed with this findings that there is a negative relationship

between exchange rate instability, inflation, and economic growth in Nigeria, emphasizing the adverse consequences of instability on the region's growth prospects.

In contrast to the long-run effects, the short-run ARDL model indicates that exchange rate volatility has a significant positive impact on Nigeria's economic growth, with a coefficient for D(REXVOL(-1)) of 315.7623 and a p-value of 0.0360. This finding suggests that in the short run, exchange rate fluctuations might temporarily stimulate economic activity, possibly by making exports more competitive or attracting speculative investment. However, these benefits appear to be transient and may not contribute to sustained economic growth. This finding agreed with the work of Boboye and Ezekiel (2023) that exchange rate fluctuations positively and significantly influences economic growth in both short run. Also, Adeniyi and Olasunkanmi (2019) agreed with this finding that there is insignificant positive relationship between exchange rate volatility and economic growth in Nigeria, suggesting the need for economic diversification and stability in exchange rates to foster sustainable growth.

5.0 Conclusion and Recommendations

This study examined the impact of exchange rate volatility on economic growth in Nigeria from 2010 to 2023 using quarterly data. The findings indicate that while exchange rate volatility may have a temporary positive effect on economic growth in the short run, it ultimately hinders long-term economic stability. This suggests that short-term fluctuations in the exchange rate might create opportunities for speculative gains or temporary boosts in trade and investment, but persistent volatility disrupts economic planning, increases uncertainty, and discourages both local and foreign investment in the long run. The study concludes that exchange rate volatility has a significant impact on economic growth in Nigeria, emphasizing the need for effective monetary and exchange rate policies to stabilize the currency and create a conducive environment for sustainable economic growth. Policymakers should focus on measures that minimize excessive fluctuations in exchange rates, such as strengthening foreign exchange reserves, diversifying the economy, and implementing policies that enhance macroeconomic stability. Based on the findings the following recommendations were made:

1. Strengthening Monetary and Fiscal Policies to Stabilize Exchange Rates: Given the persistence of exchange rate volatility in Nigeria, as identified by the ARCH and GARCH models, policymakers should implement robust monetary and fiscal policies to reduce excessive fluctuations. This includes maintaining adequate foreign exchange reserves, enhancing the effectiveness of the Central Bank's interventions in the forex market, and adopting exchange rate management policies that promote stability. By doing so, Nigeria can mitigate the long-term adverse effects of exchange rate instability on economic growth.
2. Enhancing Economic Diversification and Investment in Productive Sectors: Since the long-run ARDL model shows a significant negative impact of exchange rate volatility on economic growth, the government should prioritize economic diversification to reduce dependence on volatile foreign exchange markets. Promoting industrialization, strengthening non-oil exports, and improving the business environment for foreign direct investment (FDI) can help cushion the economy from exchange rate shocks. Additionally, targeted policies that support domestic production and reduce import reliance will contribute to long-term economic stability.

3. Encouraging Risk Management Strategies for Businesses and Investors: Given the short-run positive impact of exchange rate volatility on economic growth, businesses and investors should adopt effective hedging strategies to manage currency risks. The government and financial institutions should facilitate the use of financial instruments such as forward contracts, currency swaps, and other risk-mitigation mechanisms to protect businesses from unpredictable exchange rate movements. Additionally, enhancing financial literacy on forex risk management among businesses can help sustain growth and investment in a volatile economic environment.

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