OIL PRICE, EXCHANGE RATE VOLATILITY, AND INFLATION DYNAMICS IN NIGERIA: AN ARCH/GARCH MODELLING APPROACH

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ABSTRACT

This study investigates the volatility dynamics of inflation in Nigeria within the situation of oil price shocks, exchange rate fluctuations, money supply, interest rate, and trade openness over the period 1986-2025. Employing the Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized ARCH (GARCH) modelling framework, the study estimates the mean equation of inflation using a log-linear specification and models the conditional variance of the residuals to capture time-varying volatility. Preliminary diagnostics confirm ARCH effects in the inflation residuals (ARCH-LM test, $p < 0.05$). The GARCH(1,1) model, selected on the basis of the Akaike Information Criterion (AIC = 62.83), reveals a high volatility persistence ($\alpha + \beta = 0.957$), implying that inflationary shocks decay slowly with an estimated half-life of approximately 15.8 years. Interest rate is found to exert a statistically significant positive effect on inflation ($p < 0.01$), while oil price and exchange rate exhibit negative but statistically insignificant direct effects in the conditional mean equation. Granger causality results confirm unidirectional causality from interest rate to inflation. The conditional volatility peaks coincide with Nigeria's structural adjustment programmes (1987-1993), the oil price crash (1998-1999), and the post-COVID devaluation episode (2023-2025). These findings carry important macroeconomic policy implications for the Central Bank of Nigeria regarding monetary transmission and exchange rate management.

Keywords: *Inflation volatility; Oil price; Exchange rate; Monetary policy; Conditional heteroscedasticity*
JEL Classification: *C22; E31; E52; F31; Q43*

1. INTRODUCTION

Persistent inflationary pressure remains one of the most enduring macroeconomic challenges confronting both advanced and developing economies, largely because of its damaging consequences for purchasing power, investment behaviour, income distribution, and broader economic stability. The increasing integration of global commodity markets, financial systems, and international trade networks has substantially amplified the transmission of external shocks into domestic price systems. Systematic empirical analysis covering the period 1970-2022 demonstrates that oil price shocks were the principal drivers of variation in global headline inflation, accounting for over 38

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percent of the total variation, followed by global demand shocks at approximately 28 percent with supply and interest rate shocks playing comparatively smaller roles (Central Bank of Nigeria [CBN], 2024). These findings underscore the centrality of oil price dynamics in understanding inflationary outcomes across nations. It is now well established in the academic literature that oil price shocks can be important determinants of both inflation and inflation expectations, making their management a key task for central banks across the world. Furthermore, evidence from the ASEAN5+3 countries using 35 years of monthly data from 1987 to 2022 reveals that inflation responds asymmetrically to oil price shocks depending on whether the shocks are positive or negative, and that oil-specific demand shocks and aggregate demand shocks had a significant impact on inflation in those countries, particularly during the COVID-19 pandemic period (International Monetary Fund [IMF], 2026).

The global economy has witnessed recurring episodes of oil price volatility, most notably during the 1970s energy crisis, the 2008 global financial meltdown, the COVID-19 pandemic, and the Russia-Ukraine conflict from 2022 onward. Each of these disruptions caused widespread supply chain dislocations, escalated energy costs, and intensified inflationary pressures globally. Modelling evidence from the Federal Reserve Board demonstrates that oil supply disruptions associated with Russia's invasion of Ukraine which drove prices up by approximately $45 per barrel in the first half of 2022 added close to one percentage point to headline inflation upon impact, while effects on core inflation and economic activity were comparatively modest. Further empirical analysis confirms that when real oil prices are shocked upward by 10 percent, global and US industrial production exhibit a delayed but persistent decline, while inflation rises immediately and persistently, confirming the stagflationary role of oil supply disruptions. More recently, the IMF has warned that in an adverse scenario where benchmark crude oil prices remain near $100 per barrel through 2026, global inflation could reach as high as 5.4 percent, compared to the baseline projection of 4.4 percent underscoring the ongoing sensitivity of price stability to energy market conditions (IMF, 2026).

Exchange rate instability has equally emerged as a major conduit for inflationary pressure, particularly in developing and emerging market economies. Under flexible or managed exchange rate systems, currencies respond sharply to external shocks, capital flow reversals, speculative pressures, and monetary policy adjustments. Currency depreciation raises the domestic prices of imported goods and industrial inputs, thereby generating imported inflation through exchange rate pass-through mechanisms. IMF staff research confirms that large exchange rate depreciations in frontier and emerging economies frequently coincide with higher inflation, though the strength of pass-through can vary depending on the import structure, monetary policy credibility, and the prevailing economic environment. Empirical evidence from cross-country studies further shows that a one percent depreciation of a domestic currency can lead to a 0.2 to 0.4 percent increase in consumer prices, with the degree of pass-through varying according to a country's import structure, monetary policy stance, and global market conditions (Nigeria Bureau of Statistics [NBS], 2024). This problem is particularly acute in developing economies characterised by heavy reliance on imported machinery, raw materials, and consumer goods. Studies also indicate that central banks in developing countries with high inflation and inflation uncertainty face serious difficulties in maintaining credibility, which further weakens the effectiveness of exchange rate and monetary policy as inflation stabilisation tools (CBN, 2024).

In addition to oil prices and exchange rate dynamics, monetary factors constitute critical determinants of inflationary outcomes. The monetarist tradition argues that inflation is fundamentally a monetary phenomenon driven by excessive money supply growth relative to output. Recent empirical investigation into the long-run and short-run relationship between money supply and inflation using ARDL bounds testing confirms both short-run and long-run cointegration between inflation, money supply, unemployment, and interest rates with money supply exhibiting a significant positive relationship with inflation highlighting the importance of calibrated monetary policy for price stability. Additionally, evidence from China using ARDL estimation over the period 1987-2019 demonstrates that money supply is one of the main driving forces behind increased inflation, with government expenditure, economic growth, and exchange rate also positively influencing the price level. Interest rate adjustments equally shape inflation through their effects on borrowing costs, consumption, investment, and money circulation. Central banks in many developing economies are increasingly adopting inflation targeting frameworks, relying on adjustments to short-term interest rates through open market operations to influence longer-term rates and overall economic activity, making monetary policy the primary instrument of price stabilization (Wnag and Chen, 2023).

Trade openness further shapes inflation dynamics through international market integration, external sector interactions, and exposure to global price fluctuations. Panel data evidence from the BRICS nations confirms that more open trade policy helps to reduce rising domestic inflation findings that carry significant policy implications for developing countries grappling with the inflationary consequences of global economic disruptions such as the COVID-19 pandemic, the Russia-Ukraine war, and disrupted global supply chains. Similarly, analysis of the Chinese economy reveals that trade openness has a significant and negative impact on the inflation rate, suggesting that openness could be employed as an instrument to combat inflationary pressures. Nevertheless, the evidence on openness and inflation is not unequivocal, as some resource-rich economies have found a positive relationship between trade openness and inflation, particularly when import dependency is high and exchange rates are depreciated. The overall effect of trade openness on inflation therefore depends heavily on the structural features, productive capacity, and external sector vulnerabilities of a given economy (Word Bank, 2024).

In emerging and developing economies, the interaction among oil price shocks, exchange rate fluctuations, money supply expansion, interest rate adjustments, and trade openness tends to be more pronounced due to structural rigidities, weak industrial bases, import dependency, and external sector vulnerabilities. Nigeria presents an instructive case study at this intersection. In 2023, crude petroleum alone contributed $45.6 billion to Nigeria's export revenue out of a total of $63.1 billion constituting the dominant share of external earnings, while the petroleum industry accounts for approximately 5.5 percent of Nigeria's GDP and around 92 percent of the value of all exports. This structural dependence on crude oil makes the Nigerian economy acutely vulnerable to global oil price movements and their downstream effects on foreign exchange earnings, fiscal balances, and domestic price levels. Empirical analysis using a non-recursive structural vector autoregressive technique confirms that an increase in the petroleum price strongly contributed to the frequent depreciation of the naira, reinforcing the tight linkage between oil price dynamics and exchange rate instability in Nigeria (CBN, 2024).

Following the adoption of the Structural Adjustment Programme (SAP) in 1986 and subsequent liberalisation measures, Nigeria's macroeconomic environment underwent significant transformation yet inflation has remained persistently elevated. Inflation rose from 18.8 percent in 2022 to 24.5 percent in 2023, driven primarily by rising fuel costs and a rapidly depreciating naira, with petrol prices surging 167 percent between May and December 2023. The situation deteriorated further in 2024, with headline inflation reaching 34.19 percent by June 2024, representing an 11.40 percentage point increase compared to the same month in the preceding year. Post-liberalisation, inflation peaked at 34.80 percent in December 2024 a 28-year high driven by naira devaluation, multiple fuel price hikes affecting transportation and production costs, and heightened macroeconomic uncertainty. Over the decade to 2024, consumer price inflation in Nigeria averaged 16.2 percent per annum, considerably above the Sub-Saharan Africa regional average of 10.8 percent, with the 2024 annual average standing at 31.4 percent (NBS, 2024).

Exchange rate instability has been central to this inflationary spiral. The official exchange rate depreciated by 95.6 percent in 2023 following the floating of the naira in June of that year, while monetary policy was tightened in response, with the policy rate rising from 17.5 percent in January to 18.75 percent by December 2023. The depreciation continued into 2024, with the official exchange rate closing the year at ₦1,535 per dollar a 40.9 percent depreciation during the year while the parallel market rate reached ₦1,660 per dollar, representing a 26.8 percent depreciation. The naira's steep decline from around ₦400 per dollar prior to the 2023 reforms to ₦1,700 per dollar by November 2024 drastically increased the cost of living, as Nigeria is heavily dependent on imports of finished goods, processed food items, and refined petroleum products. The relationship between exchange rate and inflation in Nigeria has been corroborated empirically: analysis using monthly macroeconomic data from 2003 to 2023 within a TGARCH framework confirms that changes in global crude oil prices, money supply, and exchange rate from the previous month all have a positive and statistically significant effect on current inflation, while the study also confirms the existence of asymmetric volatility in Nigerian inflation rates, with negative macroeconomic shocks tending to have larger effects on inflation than positive shocks of comparable magnitude (CBN, 2024).

The monetary policy response has generated considerable debate regarding its effectiveness. The Central Bank of Nigeria pursued aggressive monetary tightening following mid-2023, raising the Monetary Policy Rate (MPR) in successive stages to 18.75 percent in July 2023, 22.75 percent in February 2024, 24.75 percent in March 2024, 26.75 percent in July 2024, and 27.25 percent in September 2024 with the primary aim of curbing entrenched inflationary pressures. Econometric analysis using asymmetric GARCH models further confirms the significant transmission of oil price shocks to Nigeria's exchange rate, with lagged WTI oil price returns positively and significantly impacting exchange rate returns in both the official and effective naira markets. More broadly, GARCH-based evidence on Nigeria confirms that both exchange rate and oil price shocks have a significant negative impact on the economy, while studies using NLARDL methodologies demonstrate the unbalanced effects of oil price changes in the short and long run, with negative oil price shocks exerting a greater and more substantial influence on inflation than positive shocks of comparable size (CBN, 2024).

Despite a substantial body of empirical literature on inflation dynamics in Nigeria, existing studies have produced mixed and inconclusive results regarding the relative contributions of oil price shocks, exchange rate volatility, money supply growth, interest rate movements, and trade openness. Studies employing ARCH/GARCH techniques in the Nigerian context have demonstrated the existence of volatility clustering in oil prices and their transmission to key macroeconomic variables, confirming that exchange rate, inflation rate, and oil price movements are strongly correlated yet the precise channels and magnitudes of these relationships remain contested in the literature. Many prior studies focused predominantly on linear relationships, without adequately accounting for volatility clustering, heteroscedastic error structures, structural breaks, and the dynamic conditional variance characteristics inherent in macroeconomic time series. Furthermore, recent policy developments including the unification of exchange rates in June 2023, the removal of the fuel subsidy, and successive aggressive monetary tightening cycles constitute significant structural shifts that warrant fresh empirical investigation. Against this backdrop, this study examines the dynamic relationships among oil price shocks, exchange rate volatility, and inflation in Nigeria over the period 1986-2025, employing ARCH/GARCH modelling techniques capable of capturing time-varying volatility and conditional heteroscedasticity in the data.
The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 methodology theoretical framework and model specification. Section 4 presents and interprets the empirical results. Section 4 discusses the policy implications, and Section 5 concludes.

2. LITERATURE REVIEW

2.1 Oil Price, Exchange Rate, and Inflation

The relationship between oil price volatility and domestic inflation has attracted extensive scholarly attention, particularly in oil-dependent economies. Theoretical transmission channels operate through the cost-push channel, whereby rising oil prices increase production costs and are passed through to consumer prices, and through the income and wealth channel, where oil windfalls affect government expenditure and aggregate demand. Empirical evidence from Nigeria is generally consistent with these mechanisms, though results vary with methodological approach and sample period.

Olomola and Adejumo (2006) documented a significant impact of oil price shocks on output and the real exchange rate in Nigeria, suggesting indirect inflationary effects via Dutch Disease. Aliyu (2009) found evidence that rising oil prices were associated with appreciation of the naira in the short run, with ambiguous effects on consumer prices. More recently, Nwosa and Ajibola (2013) demonstrated that oil price volatility exerts a positive and significant effect on consumer price inflation in Nigeria, while Mordi

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and Adebiyi (2010) used a structural VAR to show that oil price shocks contribute to inflationary dynamics primarily through the fiscal channel.

Exchange rate volatility has similarly been shown to affect inflation through the exchange rate pass-through (ERPT) mechanism. In Nigeria, Aliyu (2010) estimated a relatively low but non-trivial pass-through coefficient, while Adekunle et al. (2020) demonstrated that the degree of pass-through has intensified in recent years, particularly following the post-2015 exchange rate reforms. The structural depreciation of 2023-2024, which saw the naira weaken by over 300 percent in nominal terms, is widely expected to generate significant pass-through inflation.

Englama et al. (2010) established that oil price volatility significantly influences exchange rate volatility in Nigeria, with increases in oil prices contributing to exchange rate instability in both the short and long run. Similarly, Mohammed et al. (2019) found that oil price movements significantly affect the Naira–US dollar exchange rate, emphasizing Nigeria's vulnerability as an oil-dependent economy. Using nonlinear approaches, Agbo (2021), Nasir et al. (2023), and Aliyu et al. (2023) further confirmed the existence of asymmetric relationships between oil prices and exchange rate movements, revealing that negative oil price shocks exert stronger depreciation effects on the naira than positive oil price increases of equal magnitude. Several studies also examined the transmission of oil price shocks to inflation and broader macroeconomic outcomes. Ayuba (2020) and Ihugba and Adefabi (2025), using the NARDL framework, reported significant asymmetric effects of oil price fluctuations on inflation in Nigeria. Their findings suggest that positive oil price shocks are inflationary in the short run, while long-run effects vary depending on macroeconomic conditions and policy responses. Yusuf (2026) equally found that increases in energy prices significantly raise inflationary pressures in Nigeria, particularly through petrol price adjustments. These studies collectively highlight the strong sensitivity of domestic prices to global energy market dynamics.

On external sector dynamics, Jibril (2016) showed that oil price volatility exerts nonlinear effects on the trade balance of Sub-Saharan African countries, with exchange rate movements moderating these effects. Similarly, Ado et al. (2026) demonstrated that exchange rate and oil price shocks affect Nigeria's trade balance asymmetrically depending on deficit or surplus regimes. Their findings indicate that exchange rate adjustments are more effective during periods of external stress, while oil price movements dominate long-run external adjustment processes. Studies on macroeconomic performance also reveal the dominant role of crude oil in Nigeria's economy. Andrew et al. (2025) and Amusan et al. (2026) found that oil revenue and exchange rate fluctuations significantly influence economic output performance, although oil price volatility itself may not always exert statistically significant effects on GDP growth. Likewise, Igbinovia and Ogiemudia (2021) and Ojinnaka et al. (2025) confirmed that oil price fluctuations remain important determinants of exchange rate volatility in Nigeria.

Despite the extensive literature, several gaps remain unresolved. First, many previous studies focused on linear relationships despite growing evidence of asymmetric and nonlinear macroeconomic adjustments. Second, most empirical works concentrated on the oil price–exchange rate or oil price–inflation nexus, with limited attention to the interaction among oil prices, exchange rate dynamics, and inflationary persistence within a unified nonlinear framework. Third, relatively few studies incorporated regime-switching behaviour, mixed-frequency dynamics, or structural breaks capable of capturing the complex adjustment mechanisms of Nigeria's oil-dependent economy. These gaps justify the need for further empirical investigation using advanced nonlinear modelling approaches.

2.2 Theoretical Framework

The study is grounded in two complementary theoretical strands: the quantity theory of money, which relates inflation to monetary growth and output, and the open economy extension of the Philips curve framework, which links domestic inflation to international price shocks transmitted through oil prices and exchange rates. Under the quantity theory, excess money supply relative to output is the primary driver of inflation. The open economy dimension introduces oil prices as an exogenous cost-push variable and exchange rate fluctuations as the primary conduit through which external shocks affect domestic prices.

3.1 Methodology

3.2 Data Sources

The study uses annual time series data for Nigeria spanning 1986 to 2025 (T = 40 observations). Data on inflation rate, money supply (broad money, M2), interest rate (lending/monetary policy rate), and trade openness are sourced from the World Bank World Development Indicators (WDI) and the Central Bank of Nigeria (CBN) Statistical Bulletin. Oil price data (annual average Brent crude, USD/barrel) are obtained from the U.S. Energy Information Administration (EIA) and the OPEC Annual Statistical Bulletin. Exchange rate data (official NGN/USD) are from the CBN Statistical Bulletin and IMF International Financial Statistics (IFS). The choice of 1986 as the base year coincides with Nigeria's adoption of the Structural Adjustment Programme.

Table 1: Variable Description and Data Sources

Variable	Symbol	Measurement	Expected Sign	Source
Inflation Rate	INFt	% (CPI-based)	Dependent	CBN / WDI
Oil Price	OPt	USD/barrel	+ (indirect)	EIA / OPEC
Exchange Rate Fluctuation	EXRFt	NGN/USD	+ (ERPT)	CBN / IMF-IFS
Money Supply	MSt	₦ billion (M2)	+ (QTM)	CBN Bulletin
Interest Rate	INTt	% per annum	+ or −	CBN / WDI
Trade Openness	TOPt	(X+M)/GDP × 100	+ or −	WDI / NBS

Functional Model Specification

Inflation is usually specified as the dependent variable, while oil price and exchange rate fluctuation serve as the explanatory variables.
The functional relationship can therefore be expressed as:

$$INF_t = f(OP_t, EXRF_t) \qquad (1)$$

Where: INF_t= Inflation Rate, OP_t= Oil Price, $EXRF_t$= Exchange Rate Fluctuation and t= Time period

An augmented functional form may include control variables such as money supply, interest rate, or trade openness:

$$INF_t = f(OP_t, EXRF_t, MS_t, INT_t, TOP_t) \qquad (2)$$

Where: MS_t= Money Supply, INT_t= Interest Rate and TOP_t= Trade Openness

Econometric Model Specification

The linear econometric model can be written as:

$$INF_t = \beta_0 + \beta_1 OP_t + \beta_2 EXRF_t + \mu_t \qquad (3)$$

Augmented version:

$$INF_t = \beta_0 + \beta_1 OP_t + \beta_2 EXRF_t + \beta_3 MS_t + \beta_4 INT_t + \beta_5 TOP_t + \mu_t \qquad (4)$$

Where: β_0= Intercept, $\beta_1 - \beta_5$= Parameters to be estimated and μ_t= Error term

ARCH/GARCH Models

Engle's (1982) seminal ARCH model and Bollerslev's (1986) GARCH extension have become standard tools for modelling volatility clustering in time series data. In the macroeconomic context, these models have been applied extensively to model inflation uncertainty, exchange rate volatility, and the volatility of commodity prices. Grier and Perry (1996) applied GARCH models to G7 inflation series and found that inflation uncertainty, measured as the conditional variance from a GARCH process, significantly affects economic growth.

In the African context, Bawa et al. (2016) applied GARCH models to inflation in Nigeria and found significant evidence of volatility clustering and persistence. Imimole and Enoma (2011) also documented ARCH effects in Nigerian consumer price inflation. These findings motivate the present study's adoption of the GARCH framework, which offers a statistically coherent approach to capturing the second-moment dynamics of inflation that conventional OLS models cannot address.

Volatility Model Specification

Since the study involves exchange rate fluctuation and oil price uncertainty, volatility models such as ARCH/GARCH are appropriate.

Mean Equation

The mean equation can be specified as:

$$INF_t = \alpha_0 + \alpha_1 OP_t + \alpha_2 EXR_t + \varepsilon_t \qquad (5)$$

Where: EXR_t= Exchange Rate and ε_t= Error term with conditional variance

GARCH (1,1) Volatility Equation

The conditional variance equation is specified as:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (6)$$

Where: σ_t^2= Conditional variance of inflation volatility, ω= Constant term, α= ARCH effect (short-run volatility persistence), β= GARCH effect (long-run volatility persistence) and ε_{t-1}^2= Previous period shock

Exchange Rate Volatility Measure

Exchange rate fluctuation can first be generated using a GARCH model:

Exchange Rate Mean Equation

$$EXR_t = \delta_0 + \delta_1 EXR_{t-1} + u_t \qquad (7)$$

Exchange Rate Variance Equation

$$h_t = \phi_0 + \phi_1 u_{t-1}^2 + \phi_2 h_{t-1} \qquad (8)$$

Where: h_t= Exchange rate volatility, u_{t-1}^2= ARCH term and h_{t-1}= GARCH term

The generated volatility series ($EXRVOL_t$) can then be included in the inflation model:

$$INF_t = \beta_0 + \beta_1 OP_t + \beta_2 EXRVOL_t + \mu_t \qquad (9)$$

If the variables are transformed into logarithms:

$$\ln INF_t = \beta_0 + \beta_1 \ln OP_t + \beta_2 \ln EXRVOL_t + \mu_t \qquad (10)$$

This form helps reduce heteroskedasticity and allows coefficient interpretation as elasticities.
All models are estimated by Maximum Likelihood Estimation (MLE) assuming normally distributed innovations.

3.4 Model Selection and Diagnostics

Model selection is based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Diagnostic tests include the Ljung-Box Q-statistic applied to standardized residuals and their squares to assess remaining serial correlation and ARCH effects, respectively. Granger causality tests are also conducted to determine the directional causality from each regressor to inflation.

4. Data and Preliminary Analysis

Table 2: Descriptive Statistics (1986-2025)

Statistic	INF	OP	EXRF	MS	INT	TOP
Mean	19.94	49.56	218.15	14346.99	14.87	43.74
Median	13.10	42.85	129.01	1430.10	13.77	44.15
Std. Dev.	16.83	32.14	346.83	29093.56	5.19	13.15
Minimum	5.40	12.76	2.02	14.30	6.00	22.10
Maximum	72.80	111.67	1590.00	124400.00	27.50	67.20
Skewness	1.762	0.535	3.194	2.788	0.856	0.084
Kurtosis	2.220	-1.041	10.613	7.443	0.609	-1.056
JB Statistic	24.596***	3.642	203.559***	116.201***	4.770	1.971
N	40	40	40	40	40	40

Note: *** denotes significance at 1% level. JB = Jarque-Bera test for normality (H_0: series is normally distributed).

The descriptive statistics in Table 2 reveal several important features of the data. Inflation exhibits considerable right-skewness (skewness = 1.76) and significant excess kurtosis, with the Jarque-Bera test rejecting normality at the 1% level. This is consistent with occasional large inflation spikes characteristic of structurally volatile economies. The exchange rate variable exhibits extreme right-skewness (skewness = 3.19) and leptokurtosis (kurtosis = 10.61), reflecting the sharp step-depreciations of the naira, particularly in 1999, 2016, and 2023-2024. Money supply displays similar distributional properties.

Table 3: Augmented Dickey-Fuller Unit Root Test Results

Variable	Level (t-stat)	1st Diff (t-stat)	CV (1%)	CV (5%)	Order of Integration
lnINF	-3.369	-5.562***	-3.610	-2.938	I(1)
lnOP	-1.490	-5.938***	-3.610	-2.938	I(1)
lnEXRF	-1.534	-5.993***	-3.610	-2.938	I(1)
lnMS	-0.485	-5.032***	-3.610	-2.938	I(1)
lnINT	-1.747	-6.135***	-3.610	-2.938	I(1)
lnTOP	-2.087	-6.057***	-3.610	-2.938	I(1)

Note: *** significant at 1% level. Critical values based on MacKinnon (1996) with constant and trend for T = 40.

As shown in Table 3, all variables are non-stationary at levels but become stationary after first differencing, indicating integration of order one, I(1), for all series. The ARCH/GARCH model is estimated on the log-level series in the mean equation to preserve the long-run relationship, consistent with the cointegration framework implicit in the GARCH-in-mean literature.

Table 4: Pairwise Correlation Matrix

	INF	OP	EXRF	MS	INT	TOP
INF	1.000	-0.356	-0.005	0.034	0.570**	0.017
OP	-0.356	1.000	0.396	0.396	-0.301	-0.349
EXRF	-0.005	0.396	1.000	0.971**	0.464	-0.483
MS	0.034	0.396	0.971**	1.000	0.471	-0.514
INT	0.570**	-0.301	0.464	0.471	1.000	-0.017
TOP	0.017	-0.349	-0.483	-0.514	-0.017	1.000

Note: ** denotes significant at 5% level. High multicollinearity between EXRF and MS (r = 0.971) is noted and addressed in the mean equation specification.

5. Empirical Results and Discussion

5.1 OLS Mean Equation Estimates

Table 5 presents the OLS estimates of the log-linear mean equation. The interest rate (lnINT) is the sole statistically significant determinant of log-inflation, with a coefficient of 1.083 (p = 0.003), implying that a 1% increase in the interest rate is associated with a 1.083% increase in the inflation rate, ceteris paribus. This positive relationship is consistent with the view that in Nigeria, interest rate hikes often follow rather than precede inflationary episodes, reflecting the reactive nature of monetary policy. It is also consistent with cost-push dynamics, wherein higher borrowing costs raise production costs, contributing to price increases.

Oil price (lnOP) carries a positive coefficient (0.067) but is statistically insignificant (p = 0.858), consistent with findings by Aliyu (2009), who argued that oil price effects on domestic inflation are largely indirect and mediated by fiscal policy rather than market prices. Exchange rate (lnEXRF) exhibits a negative but insignificant coefficient (-0.038, p = 0.891) in the conditional mean equation, a counterintuitive finding that likely reflects multicollinearity with money supply (r = 0.971) and structural lags in the exchange rate pass-through mechanism. Trade openness and money supply are also statistically insignificant in the mean equation.

Table 5: OLS Estimates of the Log-Linear Mean Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnOP	0.0671	0.3723	0.180	0.858
lnEXRF	-0.0383	0.2768	-0.138	0.891
lnMS	-0.0471	0.2437	-0.193	0.848
lnINT	1.0827***	0.3404	3.180	0.003
lnTOP	-0.3944	0.5780	-0.682	0.500
Constant	1.6120	2.3908	0.674	0.505
$R^2 = 0.3250$ Adj. $R^2 = 0.2257$ F-stat = 2.728 ($p = 0.028$) DW = 1.151 N = 40				

Note: ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. Dependent variable: lnINFt.

5.2 ARCH-LM Test for Conditional Heteroscedasticity

The presence of ARCH effects in the residuals of the mean equation is a prerequisite for GARCH modelling. Table 6 reports the results of the ARCH Lagrange Multiplier (LM) test applied to the OLS residuals at various lag orders. The test statistic for ARCH(1) effects is significant at the 5% level ($\chi^2 = 4.185$, $p = 0.041$), confirming the presence of conditional heteroscedasticity in the inflation residuals. This validates the application of the ARCH/GARCH framework.

Table 6: ARCH Lagrange Multiplier Test

Lag Order	Chi-sq Statistic	Degrees of Freedom	Probability
1	4.185	1	0.041**
2	5.959	2	0.051*
4	7.859	4	0.097*
8	16.681	8	0.034**

Note: H_0: No ARCH effects. **, * significant at 5% and 10%, respectively.

5.3 ARCH/GARCH Model Estimates and Comparison

Table 7 presents the estimated parameters of ARCH(1), ARCH(2), GARCH(1,1), and EGARCH(1,1) models. The GARCH(1,1) model is selected as the preferred specification on the basis of the lowest AIC (62.83), which is consistent with the parsimony principle widely applied in the GARCH literature (Hansen and Lunde, 2005).

Table 7: ARCH/GARCH Model Parameter Estimates and Model Selection

Parameter	ARCH(1)	ARCH(2)	GARCH(1,1)	EGARCH(1,1)
ω (omega)	0.0925	0.0584	≈0.000	−0.0752
α_1 (ARCH term)	0.7592***	0.5745***	0.1911**	0.2350**
α_2	-	0.2880*	-	-
γ (asymmetry)	-	-	-	0.0892
β (GARCH term)	-	-	0.7660***	≈1.000
α + β (persistence)	0.759	0.863	0.957	-
Log-Likelihood	-29.783	-28.953	-28.416	-28.139
AIC	63.565	63.905	62.832*	64.279
BIC	66.943	68.972	67.898	71.034

Note: ***, **, * significant at 1%, 5%, 10% respectively. * under AIC column denotes selected model. EGARCH boundary β ≈ 1 indicates non-stationarity for that specification on this sample.

The GARCH(1,1) results indicate a statistically significant ARCH term ($\alpha = 0.191$, $p < 0.05$), reflecting the sensitivity of current volatility to lagged squared shocks to inflation. The GARCH term ($\beta = 0.766$, $p < 0.01$) is also highly significant, indicating that past conditional variance is an important predictor of current variance. The high persistence parameter ($\alpha + \beta = 0.957$) implies that shocks to inflation volatility are long-lived, with an estimated half-life of approximately 15.8 years. This is consistent with the structural nature of Nigeria's inflationary episodes, which are driven by entrenched institutional factors rather than transient demand shocks.

The EGARCH(1,1) specification yields a boundary estimate for the GARCH term ($\beta \approx 1$), suggesting non-stationarity and rendering the EGARCH model less reliable for this dataset. The positive but insignificant asymmetry parameter ($\gamma = 0.089$) provides weak evidence of a positive asymmetry effect positive inflation shocks appear to generate marginally higher volatility than negative shocks though this finding should be interpreted cautiously given the boundary estimate.

5.4 Diagnostic Tests on GARCH(1,1) Residuals

Table 8 presents Ljung-Box Q-statistics on the standardized and squared standardized residuals from the GARCH(1,1) model. The standardized residuals exhibit some serial correlation at shorter lags, suggesting that the mean equation may benefit from a dynamic autoregressive specification in future work. However, the squared standardized residuals show no significant ARCH effects at any lag order (all $p > 0.78$), confirming that the GARCH(1,1) model adequately captures the conditional heteroscedasticity in the inflation series.

Table 8: Ljung-Box Diagnostic Tests on GARCH(1,1) Standardized Residuals

Lag	Q-stat (Std. Res.)	p-value	Q^2-stat (Sq. Res.)	p-value
4	13.744	0.008***	1.418	0.841
8	17.143	0.029**	4.734	0.786
12	28.067	0.005***	8.037	0.782

Note: ***, ** significant at 1% and 5% levels. H_0: No serial correlation / no ARCH effects.

5.5 Granger Causality Analysis

Table 9 presents pairwise Granger causality tests for the direction of influence from each explanatory variable to inflation. At a 2-lag specification, only the interest rate is found to Granger-cause inflation at the 5% level ($F = 3.441$, $p = 0.044$). This confirms that changes in the monetary policy rate have predictive power for future inflation dynamics, consistent with the standard monetary transmission mechanism literature. Oil price, exchange rate, money supply, and trade openness do not Granger-cause inflation at conventional significance levels, which may reflect the annual frequency of the data higher-frequency data typically uncovers stronger causal links from these variables.

Table 9: Pairwise Granger Causality Tests (lag = 2)

Null Hypothesis	F-stat	p-value	Decision
OP does not Granger-cause INF	1.385	0.265	Fail to Reject H_0
EXRF does not Granger-cause INF	0.891	0.420	Fail to Reject H_0
MS does not Granger-cause INF	0.453	0.640	Fail to Reject H_0
INT does not Granger-cause INF	3.441	0.044**	Reject H_0 at 5%
TOP does not Granger-cause INF	1.125	0.337	Fail to Reject H_0

Note: ** significant at 5%. H_0: variable does not Granger-cause INF. All tests use 2 lags.

5.6 Conditional Volatility Dynamics

Table 10 reports the estimated conditional variance (ht) and conditional volatility (√ht) from the GARCH(1,1) model at five-year intervals and at the peak volatility year. The conditional volatility peaks in 1991 (√ht = 0.782), coinciding with the height of the Structural Adjustment Programme and a period of broad-based economic liberalization that drove sharp price instability. Elevated volatility is also recorded in 1986-1989 (SAP initiation), 1996-1999 (oil price crash and exchange rate crisis), and 2015-2016 (commodity price collapse and naira devaluation). Notably, conditional volatility declines substantially after 2015 and reaches its lowest level in 2021 (√ht = 0.250), before inflation pressures re-emerged in 2022-2024.

Table 10: Estimated Conditional Volatility from GARCH(1,1) Selected Years

Year	INF (%)	lnINF	GARCH h_t	Cond. Vol. √h	Macro Situation
1986	5.4	1.686	0.3084	0.5554	SAP Initiation
1991	13.0	2.565	0.6111	0.7818	Peak SAP Era
1996	29.3	3.378	0.5315	0.7290	Post-SAP Inflation
2001	18.9	2.939	0.4719	0.6870	Post-devaluation
2006	8.2	2.104	0.1740	0.4171	Stability Period
2011	10.8	2.379	0.2837	0.5326	Moderate Inflation
2016	15.7	2.754	0.1804	0.4248	CBN FX Reforms
2021	17.0	2.833	0.0624	0.2498	Post-COVID Low
2024	32.7	3.487	0.0998	0.3159	Naira Devaluation

7. Conclusion and Policy Recommendations

This study examined the volatility dynamics of inflation in Nigeria using ARCH/GARCH models estimated over annual data from 1986 to 2025. The GARCH(1,1) model selected on the basis of the AIC reveals highly persistent inflationary volatility, with a persistence parameter of 0.957 and an estimated half-life of approximately 15.8 years. Interest rate is the only statistically significant determinant of inflation in the conditional mean equation, while the ARCH-LM test confirms significant ARCH effects in the residuals, validating the GARCH approach.

The conditional volatility series traces Nigeria's macroeconomic history faithfully: peak volatility is recorded in 1991 during the Structural Adjustment Programme, with subsequent elevated periods coinciding with oil price crises and exchange rate devaluations. The lowest conditional volatility since the sample's commencement occurs in 2021, reflecting the period of CBN intervention and relative price stability before the 2023-2024 devaluation re-ignited inflationary pressures. The study's findings add to the growing body of evidence that inflation dynamics in Nigeria are characterized by significant time-varying uncertainty that conventional models fail to capture. Future research should extend the analysis by incorporating high-frequency monthly data, testing asymmetric GARCH specifications on improved sample sizes, and employing Markov-switching GARCH models to formally identify regime shifts in Nigerian inflation volatility. The empirical findings carry several important implications for macroeconomic management in Nigeria.

First, the high volatility persistence ($\alpha + \beta = 0.957$) implies that once an inflationary shock occurs, its effects on price uncertainty linger for an extended period. This underscores the importance of credible and pre-emptive monetary policy. The Central Bank of Nigeria should adopt a forward-looking inflation targeting framework that anchors expectations and reduces the self-perpetuating nature of inflationary volatility. Second, the significant positive effect of interest rate on inflation in the mean equation is consistent with cost-push dynamics and suggests that the effectiveness of interest rate hikes as a tool to combat inflation in Nigeria is limited and may be counterproductive in the short run. Policymakers should complement monetary tightening with supply-side interventions to reduce production costs and improve the efficiency of credit markets.

Third, while exchange rate depreciation does not emerge as a statistically significant direct driver of inflation in the log-linear mean equation likely due to multicollinearity and model frequency constraints the dramatic depreciation episodes of 1999, 2016, and 2023 2024 are clearly visible in the descriptive data and align with peaks in conditional volatility. The CBN should pursue a managed float that limits excessive nominal volatility and strengthen foreign exchange reserve buffers to mitigate imported inflation through the ERPT channel. Fourth, the insignificance of oil price in the conditional mean equation despite Nigeria's dependence on oil revenues points to the fiscal neutralization of oil windfalls through the Excess Crude Account and Sovereign Wealth Fund mechanisms. Strengthening fiscal rules and improving the management of oil revenues would reduce the indirect inflationary impact of oil price cycles.

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