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MODELLING INFLATION DYNAMICS: A STATISTICAL INVESTIGATION OF FUEL PRICE, MONEY SUPPLY, AND EXCHANGE RATE

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ABSTRACT

Persistent inflation remains a central challenge in Nigeria's macroeconomic landscape, raising questions about the true drivers of price instability in recent years. This study explores the interconnected roles of money supply (M2), fuel price, and exchange rate (EXR) in explaining inflationary dynamics using monthly data from January 2020 to December 2024. Leveraging the Vector Error Correction Model (VECM), the analysis captures both short-run fluctuations and long-run equilibrium relationships. Results from the Johansen cointegration test reveal two stable long-run relationships, particularly highlighting the strong link between inflation and exchange rate movements. Granger causality analysis identifies exchange rate and money supply as significant short-run predictors of inflation, while impulse response functions confirm that exchange rate shocks produce the most persistent inflationary effects. Interestingly, fuel price exerts limited short-term influence on inflation, suggesting the moderating role of domestic price controls. Residual diagnostic tests validate the model's robustness. Overall, the findings underscore the critical importance of exchange rate management and monetary discipline in curbing inflation, offering timely insights for policymakers navigating Nigeria's post-subsidy and post-pandemic economic recovery.

Keywords: Inflation, Money Supply, Exchange Rate, Fuel Price, VECM, Granger Causality

INTRODUCTION

Inflation in Nigeria, characterized by a persistent rise in the general price level, continues to pose substantial threats to economic stability, development, and the welfare of citizens. The consequences of inflation are far-reaching: it erodes real incomes, distorts savings and investment decisions, and imposes uncertainty on economic planning. Despite policy interventions, inflation in Nigeria has remained stubbornly high, often surpassing the Central Bank of Nigeria's (CBN) target range (Akinbobola, 2012; IMF, 2022).

Inflation remains a persistent macroeconomic challenge in Nigeria, driven by a complex interplay of monetary, fiscal, and external factors. Understanding the key drivers of inflation is critical for policymakers seeking to maintain price stability and promote sustainable economic growth.

Inflation, characterized by a sustained increase in the general price level, is one of the most pressing macroeconomic challenges facing Nigeria. Persistent inflation undermines purchasing power, increases the cost of living, and distorts economic decision-making for households and businesses. Nigeria's inflationary trends have historically been shaped by various domestic and external shocks, including rising energy prices, exchange rate instability, and expansionary monetary policies.

In 2023 and 2024, Nigeria witnessed renewed inflationary surges driven by key macroeconomic disruptions such as the removal of fuel subsidies, substantial naira depreciation, and monetary expansion. The consumer price index (CPI) peaked at over 28% in 2024 before easing modestly to 22.22% in June 2025, supported by a tight monetary stance (Reuters, 2025a). These developments have drawn attention to the interplay between inflation and critical macroeconomic indicators such as fuel price, money supply, and exchange rate.

Despite the Central Bank of Nigeria's policy efforts to control inflation through monetary tightening and foreign exchange interventions, inflation rates have remained stubbornly high. Traditional policy tools have often fallen short due to structural bottlenecks and weak policy transmission mechanisms. Hence, a rigorous statistical modeling framework is needed to understand the inflationary process and provide a basis for more informed and effective policymaking.

Empirical studies have widely applied cointegration-based econometric models to investigate macroeconomic relationships in Nigeria. For instance (Kuhe et al., 2025) examined the interaction between stock market prices and exchange rate movements using a cointegrated VAR framework and reported the existence of significant long-run relationships among the variables in Nigeria's financial system. Their findings demonstrate the suitability of cointegration-based models in capturing long-run macroeconomic dynamics in developing economies.

Exchange rate fluctuations have been widely identified as a major driver of inflation in developing economies due to strong import dependence and exchange rate pass-through effects (Ademola and Adebayo, 2021; Olayemi, 2022). Monetary expansion has also been linked to inflationary pressures in Nigeria through liquidity growth and aggregate demand expansion (Kumeka and Egwakhe, 2022).

Further studies have shown that monetary policy instruments influence inflation through both direct and indirect channels within the Nigerian economy (Afolabi and Aliyu, 2023).

Recent inflationary trends are increasingly linked to fluctuations in fuel prices, changes in the money supply, and exchange rate volatility. However, the relative impact and interrelationships among these macroeconomic indicators remain insufficiently explored using comprehensive statistical tools.

Although various studies have examined individual determinants of inflation in Nigeria, there is a gap in the literature regarding integrated time series modeling of multiple macroeconomic variables. Few studies have employed vector error correction models (VECM), cointegration analysis, and Granger causality tests in a unified framework to assess both short-term and long-term dynamics. This research addresses this methodological gap by statistically modeling inflation in the Nigerian context using monthly data from 2020 to 2024.

This aim of this research is to statistically model the impact of fuel price, money supply, and exchange rate on inflation in Nigeria using time series techniques. The Objectives are:

1. To assess the time series properties (stationarity, trends) of inflation, fuel price, money supply, and exchange rate.
2. To estimate the short-run and long-run relationships between inflation and its predictors.
3. To determine the direction of causality among the variables using Granger causality tests.

This study provides a statistical framework for understanding the behavior of inflation in Nigeria through rigorous quantitative analysis. It offers policymakers, economists, and academics valuable insights into which variables matter most and how they interact over time.

It also contributes to the existing literature by applying modern time series techniques like cointegration analysis, vector error correction modeling (VECM), and Granger causality within a Nigerian context.

MATERIALS AND METHODS

This study adopted a quantitative time series econometric framework to analyze the dynamic relationship between inflation and selected macroeconomic variables in Nigeria. Specifically, the research utilized the Vector Error Correction Model (VECM) to investigate both short-run and long-run interactions between inflation (INF), fuel price (FUEL), broad money supply (M2), and exchange rate (EXR).

The analysis was based on monthly time series data spanning from January 2020 to December 2024, resulting in 60 observations for each variable obtained from the central Bank of Nigeria official website. The analysis was performed using python software.

Model Specification

Model Variables and Vector Definition

Let the vector of endogenous macroeconomic variables be defined as:

$$Y_t = \begin{bmatrix} INF_t \\ FUEL_t \\ M2_t \\ EXR_t \end{bmatrix} \quad (1)$$

INF – Monthly inflation rate
FUEL – Domestic fuel price (in Naira)
M2 – Broad money supply (monetary aggregate)
EXR – Official Naira/US Dollar exchange rate

Stationary Testing

To determine the time series properties of the variables, the Augmented Dickey-Fuller (ADF) test was applied to each series. This test assesses the presence of unit roots, thereby indicating whether a variable is stationary at level or requires differencing

The ADF test is expressed as:

$$yt = \alpha + \rho y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta y_{t-i} + \beta_t + \varepsilon_t \quad (2)$$

Null Hypothesis (H_0): The time series has a unit root (non-stationary).

Alternative Hypothesis (H_1): The time series does not have a unit root (stationary).

Decision Rule: If the ADF test statistic is less than the critical value and the p-value is below 0.05, reject H_0.

Lag Length Selection

The optimal lag length for modeling was determined using the Akaike Information Criterion (AIC) within a multivariate framework. Lag lengths up to 12 were considered, and the selected lag ensured an adequate balance between dynamic richness and parsimony, particularly for the subsequent cointegration and VECM analysis.

$$\text{AIC (p)} = ln\left|\Sigma_p\right| + \frac{2k^2p}{T} \quad (3)$$

Where:
$\Sigma_p =$ Estimated residual covariance matrix
K= number of endogenous variables
T= sample size
The lag p that minimizes AIC is chosen, subject to degrees-of-freedom considerations.

Vector Error Correction Model (VECM)

Upon confirmation of integration, a Vector Error Correction Model (VECM) was estimated. The model includes four endogenous variables (INF, FUEL, M2, and EXR), an integration rank determined by the Johansen procedure, and lagged differences to capture short-run dynamics. The VECM accounts for both:
Long-run relationships via the integration term
Short-run adjustments via lagged differenced variables
The general structure of the VECM is expressed as:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \mu + \varepsilon_t \quad (4)$$

Where:
ΔY_t Is the vector of first-differenced endogenous variables?
α Is the matrix of adjustment coefficients?
β Contains the integrating vectors,
Γ_i Are matrices of short-run coefficients?
μ Is a constant term, and
ε_t Is the error term.
The VECM was estimated using Python's stats models package.

Post-Estimation Procedures

Granger Causality Tests

To examine short-run predictive relationships among the variables.
Variable X Granger- causes Y if:

$$H_0: \Gamma_{yx,1} = \gamma_{yx,2} = \ldots = \gamma_{yx,p-1} = 0 \quad (5)$$

Rejection of H_0 implies predictive causality from X to Y

Impulse Response Functions (IRFs)

Impulse Response Functions were generated to trace the time path of inflation's response to one-standard-deviation shocks in each of the independent variables (FUEL, M2, and EXR). IRFs were computed over a 12-month horizon to assess the duration and magnitude of each shock.
The VECM can be transformed into its moving-average representation:

$$Y_t = \sum_{i=0}^{\infty} \psi_i \, \varepsilon_{t-i} \quad (6)$$

An inpulse response traces: $\frac{\partial Y_{t+h}}{\partial \varepsilon_t}$ (7)

Residual Diagnostics

Autocorrelation (Ljung-Box test)

$$Q = n(n+2) \sum_{k=1}^{m} \frac{\hat{\rho}_k^2}{n-k} \quad (8)$$

Where:
Q = Ljung-Box test statistic
n = number of observations (residuals)
m= number of lags being tested
$\hat{p}_k$ = sample autocorrelation at lag k

RESULTS AND DISCUSSION

Descriptive Statistics and Time Series Overview

This section presents the descriptive characteristics of the variables used in the study: inflation rate (INF), fuel price (FUEL), broad money supply (M2), and exchange rate (EXR). Monthly data from January 2020 to December 2024 were used, yielding 60 observations per variable.

Descriptive Statistics
Table 1 displays the summary statistics for each variable, including the mean, standard deviation, minimum, maximum, and quartiles. These statistics provide a preliminary understanding of the distribution and variability of the data over the study period

Table 1: Summary Statistics of Variables (2020–2024)

	INF	FUEL	M2	EXR
Count	60.000000	60.000000	60.000000	60.000000
mean	21.331667	338.931333	57436405	660.096481
std	7.238503	266.135580	25371550	440.326988
min	12.130000	128.880000	29132380	306.455000
25%	15.737500	165.000000	38419280	379.539474
50%	19.120000	166.075000	48705480	415.988196
75%	26.872500	614.000000	67466930	776.471893
max	34.800000	1065.000000	113075855.1	1670.276429

These statistics reveal the general trends and dispersion in the data. For instance, the inflation rate and fuel price exhibited considerable variation during the period, consistent with Nigeria's economic conditions between 2020 and 2024.

Time Series Behavior
Figure 1 shows the time series plots for each of the variables across the study period. These plots help visualize the patterns, seasonality, and potential structural breaks in the data.

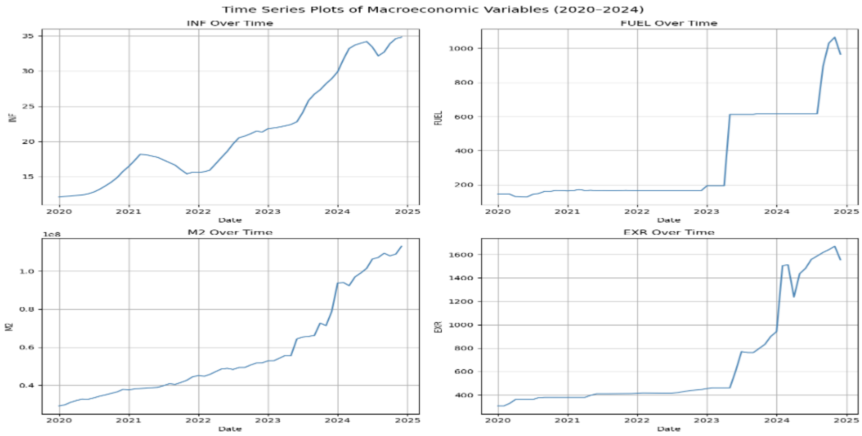

Figure 1: Monthly Trends in Macroeconomic Variables (2020–2024)

Inflation starts around 15% in 2020, rises with fluctuations (a dip around 2021-2022), and then increases sharply from 2023, reaching approximately 35% by mid-2025. The sharp rise in 2023-2025 suggests significant inflationary pressure, possibly due to supply shocks, monetary expansion, or external factors like fuel price increases or exchange rate depreciation. This trend indicates a potential economic challenge, requiring policy responses to control inflation.
Fuel prices remain relatively stable around 200-300 units from 2020 to 2023, then jump sharply to around 1000 units in 2024-2025. The sudden increase in 2024 suggests a significant shock, possibly due to global oil price surges, supply disruptions, or policy changes (e.g., subsidy removal). Higher fuel prices could contribute to cost-push inflation, affecting INF and other economic variables.
M2 starts at around 0.4 (in 10^8 units) in 2020, shows a gradual increase through 2022-2023, and then rises steeply to about 1.1 by mid-2025. The rapid growth in 2023-2025 aligns with the inflation surge, suggesting a possible link between money supply expansions and rising prices. This monetary expansion could be a driver of inflation, consistent with the quantity theory of money, and may reflect aggressive fiscal or monetary policy.
The exchange rate remains stable around 400-500 units from 2020 to 2023, then increases sharply to around 1600 units by mid-2025. The steep rise in 2024-2025 indicates significant currency depreciation, which could be due to capital outflows, trade imbalances, or reduced foreign reserves.
Depreciation often leads to higher import costs (e.g., fuel), contributing to inflation, which aligns with the observed INF and FUEL trends.

Correlation
The sharp increases in M2, FUEL, and EXR from 2023-2025 coincide with the rapid rise in INF, suggesting a potential causal relationship. Increased money supply (M2) and higher import costs (due to EXR depreciation and FUEL price shocks) likely drive inflation.
The period 2020-2022 shows relative stability, while 2023-2025 reflects a period of economic turbulence, possibly exacerbated by global events (e.g., post-pandemic recovery, geopolitical tensions) or domestic policy shifts.

Correlation Matrix
For additional insight, a correlation matrix was computed to examine the linear relationship among the variables.

Table 2: Pairwise Correlation Matrix

	INF	FUEL	M2	EXR
INF	1.000000	0.889769	0.972490	0.922291
FUEL	0.889769	1.000000	0.911748	0.894480
M2	0.972490	0.911748	1.000000	0.967313
EXR	0.922291	0.894480	0.967313	1.000000

The correlation matrix provides pairwise correlation coefficients between the macroeconomic variables, Inflation (INF), Fuel prices (FUEL), Money supply (M2), and Exchange rate (EXR) indicating the strength and direction of their linear relationships. Below is an interpretation of the matrix, followed by its linkage to the time series trends and impulse response functions (IRFs) discussed earlier.

i. INF with FUEL: 0.889769 (Strong positive): A high positive correlation suggests that as fuel prices increase, inflation tends to rise, consistent with cost-push inflation.
ii. INF with M2: 0.972490 (Very strong positive): A very high positive correlation indicates that increases in money supply are strongly associated with rising inflation, aligning with monetary theory.
iii. INF with EXR: 0.922291 (Strong positive): A strong positive correlation implies that exchange rate depreciation (higher EXR) is linked to higher inflation, likely due to increased import costs.
iv. FUEL with M2: 0.911748 (Strong positive): A strong positive correlation suggests that money supply growth is associated with rising fuel prices, possibly through increased demand or policy effects.
v. FUEL with EXR: 0.894480 (Strong positive): A strong positive correlation indicates that exchange rate depreciation is linked to higher fuel prices, likely due to imported fuel costs.
vi. M2 with EXR: 0.967313 (Very strong positive): A very high positive correlation suggests that money supply expansion is closely tied to exchange rate depreciation, possibly due to monetary policy or capital flow dynamics.

The correlation matrix confirms strong interdependencies among INF, FUEL, M2, and EXR, with M2 and EXR showing the highest correlations with INF (0.972 and 0.922), aligning with their significant time series increases

The economic narrative from 2020-2025 suggests a feedback loop: M2 expansion (e.g., post-pandemic stimulus) led to EXR depreciation and FUEL price shocks, all driving INF upward.

Stationarity Test Results

Before proceeding with cointegration analysis, the stationarity properties of each variable were examined using the Augmented Dickey-Fuller (ADF) test. Stationarity is essential in time series modeling to avoid spurious regressions and to determine the appropriate transformation for each series.

The ADF test was applied to the level form of each variable: inflation rate (INF), fuel price (FUEL), money supply (M2), and exchange rate (EXR). The null hypothesis of the ADF test is that the series has a unit root (non-stationary), while the alternative is that the series is stationary.

Table 3: ADF Test on the Original Variables

	Test Statistic	P-value
INF	1.9600	0.9986
FUEL	0.3250	0.9785
M2	2.0329	0.9987
EXR	-2.6535	0.0824

All four variables failed to reject the null hypothesis at level form, indicating the presence of unit roots. (Table 3)

To determine the order of integration, the ADF test was re-applied to the first differences of each variable.

While inflation, fuel price, and money supply became stationary after first differencing, the exchange rate (EXR) remained non-stationary even in first difference form, which is atypical for macroeconomic time series.

Table 4: ADF Test Results at First Differences

	Test Statistic	P-value
INF	-3.2947	0.0151
FUEL	-6.6170	0.0000
M2	-3.2227	0.0187
EXR	-1.6398	0.4624

Given the persistent non-stationarity of EXR (table 4), the series was visually examined for potential structural breaks. A clear shift in pattern was observed beginning around 2022, suggesting that different regimes may exist within the full sample.

To further investigate, the exchange rate series was split into two sub-periods:

Period 1: January 2020 – December 2021

Period 2: January 2022 – December 2024

The ADF test was then re-applied separately to each sub-period.

The results confirm that the EXR was stationary during 2020–2021 but became non-stationary in the later period (Table 5). This suggests the presence of a structural break in the exchange rate dynamics, likely reflecting changes in macroeconomic policy or exchange rate management.

Table 5: ADF Test on EXR Sub-Periods

Sub-group	Test Statistic	P-value
EXR (2020–2021)	-3.3469	0.0129
EXR (2022–2024)	-0.2395	0.9337

Conclusion on Stationarity

The ADF test results indicate that inflation (INF), fuel price (FUEL), and money supply (M2) are non-stationary at levels but become stationary after first differencing, confirming that they are integrated of order one, I(1).

The exchange rate (EXR), however, remained non-stationary even at first difference when the full sample was considered. A further structural break analysis revealed that the EXR was stationary during the 2020–2021 sub-period but became non-stationary from 2022 onward, suggesting a shift in the data-generating process, possibly due to macroeconomic disruptions or exchange rate policy changes.

Despite this, the full sample EXR series was retained for subsequent cointegration analysis. This decision was based on the understanding that structural breaks are common in macroeconomic data and do not necessarily invalidate cointegration methods such as the Johansen test, particularly when the system as a whole is well-behaved. The inclusion of EXR also allows for a complete representation of the inflationary dynamics under study.

Lag Length Selection and Johansen Cointegration Test

Before estimating the Vector Error Correction Model (VECM), it is necessary to determine the appropriate number of lags to include in the system. Additionally, a cointegration test is required to establish the existence and number of long-run equilibrium relationships among the integrated variables.

Table 6a: AIC and BIC of Selected Lag Order

Lag	AIC	BIC
0	46.25	47.19
1	45.40	46.98
2	44.57	46.78
3	44.51	47.34
4	43.73	47.19
5	43.50	47.59
6	40.65	45.38
7	38.35	43.71
8	37.10	43.09
9	33.67	40.28
10	5.051	12.29
11	-84.56	-76.69
12	-88.41	-79.91

Although the Akaike Information Criterion (AIC) continued to decline as the lag length increased up to 12 (table 6a), this study selected a lag length of six (6). This decision balances model performance with the need to preserve degrees of freedom given the limited sample size (60 monthly observations). Choosing a more parsimonious model with lag 6 ensures greater reliability and avoids overfitting, which could arise with longer lags in small samples.

The Johansen cointegration test (table 6b) was performed on the level series using a lag structure of 6 (i.e, 5 lagged differences). The results indicate that the trace statistics for rank 0 and rank 1 exceed the 5% critical values, while the test for rank 2 does not. This implies that there are exactly two cointegration relationships among the four variables, confirming the presence of long-run equilibrium dynamics.

Table 6b: **Johansen Cointegration Test**; ***Johansen Cointegration Test using Trace Test Statistic with 5% Significance Level***

Null hypothesis rank (r)	Alternative (r≥)	Trace statistic	5% critical value	Conclusion
r=0	r≥1	123.9	55.25	Reject
r≥1	r≥2	48.82	35.01	Reject
r≤2	r≥3	11.49	18.40	Fail to reject

The outcome of the lag length selection and Johansen cointegration test provided a solid empirical basis for estimating a VECM with lag 6 and cointegration rank 2. The presence of cointegration justifies the use of the Vector Error Correction Model (VECM), which captures both the short-run dynamics and long-run equilibrium relationships among the macroeconomic variables in the model.

Vector Error Correction Model (VECM) Estimation

The cointegration vectors presented in Table 7a reveal two long-run relationships: one linking inflation (INF) to exchange rate (EXR), and another linking fuel price (FUEL) to EXR.

Table 7a: Long-Run Cointegration Relationships (Beta)

	β_1	B_2
INF	1.0000	0.0000
FUEL	0.0000	1.0000
M2	0.0000	0.0000
EXR	0.0178	0.0815

The adjustment coefficients in Table 7b show that INF has a negative error correction term (−0.1024) in the first equation, indicating it adjusts toward equilibrium aftershocks. EXR and FUEL have large positive coefficients, implying stronger corrections in response to disequilibrium.

Table 7b: Speed of Adjustment Coefficients (Alpha)

	EC1	EC2
INF	-0.1024	0.0017
FUEL	20.3526	-0.3401
M2	-991223.2545	17620.8325
EXR	3.3278	-0.1450

Short-run dynamics presented in Tables 8a to 8d show the effects of lagged changes in all variables. While ΔM2 shows weak and statistically insignificant effects across all equations, INF and EXR show more immediate short-run interactions.

Short-Run Dynamic Coefficients (Gamma)

Table 8a: Equation for ΔINF

	ΔINF	ΔFUEL	ΔM2	ΔEXR
Lag 1	0.7255	-0.0007	0.0	-0.0035
Lag 2	-0.3732	0.0015	0.0	-0.0023
Lag 3	0.1797	0.0010	0.0	-0.0024
Lag 4	0.2243	-0.0020	0.0	-0.0011
Lag 5	-0.0374	0.0009	0.0	-0.0025

Table 8b: Equation for ΔFUEL

	ΔINF	ΔFUEL	ΔM2	ΔEXR
Lag 1	-10.1297	0.3236	0.0	-0.7806
Lag 2	-14.2393	0.3055	0.0	-0.1410
Lag 3	-54.2320	0.0902	0.0	-0.1221
Lag 4	107.7585	0.0227	-0.0	-0.0835
Lag 5	-107.0268	0.4014	-0.0	-0.3514

Table 8c: Equation for ΔM2

	ΔINF	ΔFUEL	ΔM2	ΔEXR
Lag 1	-2438664	-7644.1273	-0.3265	-9684.2727
Lag 2	2133759	-5649.3854	0.0812	-18151.5322
Lag 3	-964247.1	10406.6516	1.2491	-3584.9996
Lag 4	598368	-17895.1580	0.0590	5412.9710
Lag 5	3496993	6175.7521	-0.0359	807.6260

Table 8d: Equation for ΔEXR

	ΔINF	ΔFUEL	ΔM2	ΔEXR
Lag 1	-15.5036	0.4441	0.0	-0.8310
Lag 2	-12.6829	0.4217	0.0	-0.7484
Lag 3	32.3468	0.0494	0.0	-0.6335
Lag 4	-25.0454	0.4410	0.0	-0.2608
Lag 5	34.0083	0.1379	0.0	0.0485

Short-Run Equations

ΔINF = -0.1024*EC1 + 0.0017*EC2 + 0.7255*ΔINF(t-1) + -0.0007*ΔFUEL(t-1) + 0.0000*ΔM2(t-1) + -0.0035*ΔEXR(t-1) + -0.3732*ΔINF(t-2) + 0.0015*ΔFUEL(t-2) + 0.0000*ΔM2(t-2) + -0.0023*ΔEXR(t-2) + 0.1797*ΔINF(t-3) + 0.0010*ΔFUEL(t-3) + 0.0000*ΔM2(t-3) + -0.0024*ΔEXR(t-3) + 0.2243*ΔINF(t-4) + -0.0020*ΔFUEL(t-4) + 0.0000*ΔM2(t-4) + -0.0011*ΔEXR(t-4) + -0.0374*ΔINF(t-5) + 0.0009*ΔFUEL(t-5) + 0.0000*ΔM2(t-5) + -0.0025*ΔEXR(t-5)

ΔFUEL = 20.3526*EC1 + -0.3401*EC2 + -10.1297*ΔINF(t-1) + 0.3236*ΔFUEL(t-1) + 0.0000*ΔM2(t-1) + -0.7806*ΔEXR(t-1) + -14.2393*ΔINF(t-2) + 0.3055*ΔFUEL(t-2) + 0.0000*ΔM2(t-2) + -0.1410*ΔEXR(t-2) + -

54.2320*ΔINF(t-3) + 0.0902*ΔFUEL(t-3) + 0.0000*ΔM2(t-3) + -0.1221*ΔEXR(t-3) + 107.7585*ΔINF(t-4) + 0.0227*ΔFUEL(t-4) + -0.0000*ΔM2(t-4) + -0.0835*ΔEXR(t-4) + -107.0268*ΔINF(t-5) + 0.4014*ΔFUEL(t-5) + -0.0000*ΔM2(t-5) + -0.3514*ΔEXR(t-5)

ΔM2 = -991223.2545*EC1 + 17620.8325*EC2 + -2438664.2377*ΔINF(t-1) + -7644.1273*ΔFUEL(t-1) + -0.3265*ΔM2(t-1) + -9684.2727*ΔEXR(t-1) + 2133759.1170*ΔINF(t-2) + -5649.3854*ΔFUEL(t-2) + 0.0812*ΔM2(t-2) + -18151.5322*ΔEXR(t-2) + -964247.1354*ΔINF(t-3) + 10406.6516*ΔFUEL(t-3) + 1.2491*ΔM2(t-3) + -3584.9996*ΔEXR(t-3) + 598367.9696*ΔINF(t-4) + -17895.1580*ΔFUEL(t-4) + 0.0590*ΔM2(t-4) + 5412.9710*ΔEXR(t-4) + 3496993.0541*ΔINF(t-5) + 6175.7521*ΔFUEL(t-5) + -0.0359*ΔM2(t-5) + 807.6260*ΔEXR(t-5)

ΔEXR = 3.3278*EC1 + -0.1450*EC2 + -15.5036*ΔINF(t-1) + 0.4441*ΔFUEL(t-1) + 0.0000*ΔM2(t-1) + -0.8310*ΔEXR(t-1) + -12.6829*ΔINF(t-2) + 0.4217*ΔFUEL(t-2) + 0.0000*ΔM2(t-2) + -0.7484*ΔEXR(t-2) + 32.3468*ΔINF(t-3) + 0.0494*ΔFUEL(t-3) + 0.0000*ΔM2(t-3) + -0.6335*ΔEXR(t-3) + -25.0454*ΔINF(t-4) + 0.4410*ΔFUEL(t-4) + 0.0000*ΔM2(t-4) + -0.2608*ΔEXR(t-4) + 34.0083*ΔINF(t-5) + 0.1379*ΔFUEL(t-5) + 0.0000*ΔM2(t-5) + 0.0485*ΔEXR(t-5)

Long-Run Cointegration Equations

Cointegration Equation 1: 1.0000*INF + 0.0000*FUEL + -0.0000*M2 + 0.0178*EXR = 0

Cointegration Equation 2: 0.0000*INF + 1.0000*FUEL + 0.0000*M2 + 0.0815*EXR = 0

Granger Causality Tests

The results in Table 9a reveal that money supply (M2) and exchange rate (EXR) significantly Granger-cause inflation (INF), indicating they have short-run predictive power. Additionally, INF Granger-causes FUEL, suggesting feedback between inflation and energy pricing. However, FUEL and EXR do not Granger-cause INF, and M2 does not Granger-cause EXR, though EXR does Granger-cause M2.

Table 9a: Granger Causality

Caused	Causing	p-value	Conclusion
INF	FUEL	0.4084	No causality
INF	M2	0.0036	Granger-cause
INF	EXR	0.0203	Granger-cause
FUEL	INF	0.0017	Granger-cause
FUEL	M2	0.1533	No causality
FUEL	EXR	0.1171	No causality
M2	INF	0.1544	No causality
M2	FUEL	0.0002	Granger-cause
M2	EXR	0.3988	No causality
EXR	INF	0.0404	Granger-cause
EXR	FUEL	0.0037	Granger-cause
EXR	M2	0.0000	Granger-cause

Impulse Response Functions (IRFs)

The impulse response plots shown in Figure 2 indicate that a one-standard-deviation shock to EXR produces a sharp and sustained increase in INF, peaking between the third and fourth month. A shock to M2 causes a gradual rise in INF, while FUEL shocks lead to a much smaller and delayed inflationary effect.

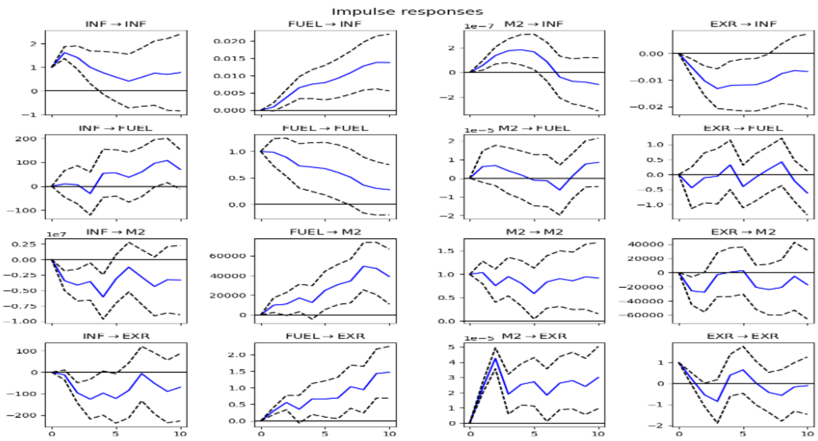

Figure 2: Plots of the Impulse Responses

Residual Diagnostics

The Ljung-Box and Jarque-Bera test results in Table 10 show that residuals for INF, M2, and EXR are normally distributed and free from autocorrelation. However, the FUEL residuals fail the normality test, suggesting a potential modeling concern for this variable.

Table 10: Residual Diagnostic Tests

Indicators	Ljung-Box Test (p-value)	Jarque-Bera Normality Test (p-value)
INF	0.4225	0.4976
FUEL	0.7497	0.0000
M2	0.5219	0.6381
EXR	0.0829	0.7839

Visual diagnostics in Figure 3 confirm these findings. The residual histograms and Q-Q plots for INF, M2, and EXR follow the expected normal distribution pattern, while the FUEL residuals show heavy tails and deviation from normality

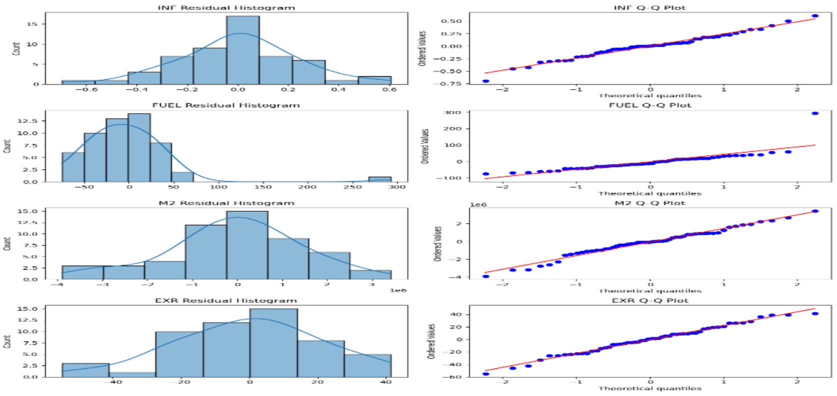

Figure 3: Residual Plots

CONCLUSION

This study examined the dynamic relationship between inflation, fuel price, money supply (M2), and exchange rate in Nigeria using monthly data from January 2020 to December 2024 within a Vector Error Correction Model (VECM) framework. Unit root tests confirmed that the variables were integrated of order one, while the Johansen cointegration test revealed the presence of two long-run equilibrium relationships among the variables. The results therefore indicate that inflation dynamics in Nigeria are influenced by long-term interactions between macroeconomic and external sector variables.

The estimated VECM results showed that exchange rate movements play a dominant role in explaining inflation behaviour in Nigeria. The impulse response analysis further confirmed that shocks to the exchange rate produce the most significant response in inflation compared with shocks from money supply and fuel price. Granger causality results indicated that money supply and exchange rate significantly influence inflation dynamics, while inflation also exhibits feedback effects on fuel price movements.

Overall, the findings suggest that inflation in Nigeria is strongly linked to exchange rate fluctuations and monetary expansion. Effective inflation management therefore requires a coordinated policy framework that combines exchange rate stability with prudent monetary control. Strengthening foreign exchange market stability and maintaining disciplined liquidity management will be critical in reducing inflationary pressures and ensuring long-term macroeconomic stability.

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